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Final Report

Industrial Policies for Value Addition and Economic Diversification in Energy Transition Value Chains: A Comparative Study of Namibia, Zambia, and Madagascar

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Table of Abbreviations

AfCFTA	African Continental Free Trade Area
ARP	Applied Research Project
CAT	Chain Analysis Tool
CETM	Critical Energy Transition Minerals
CICE	Clean Industrial Capabilities Explorer
COMESA	Common Market for Eastern and Southern Africa
DRC	Democratic Republic of Congo
ECI	Economic Complexity Index
EQuIP	Enhancing the Quality of Industrial Policies
FDI	Foreign Direct Investment
FELDA	Federal Land Development Authority
FPIC	Free, Prior and Informed Consent
GDP	Gross Domestic Product
GNI	Gross National Income
GPRVC	Geneva Platform for Resilient Value Chains
HS	Harmonised System
IAP	Industrial Analytics Platform
IHEID	Institut de Hautes Études Internationales et du Développement (Geneva Graduate Institute)
IMF	International Monetary Fund
IRA	Inflation Reduction Act
LFP	Lithium Iron Phosphate
NIPDB	Namibia Investment Promotion and Development Board
NIPO	New Industrial Policy Observatory

OEC	Observatory of Economic Complexity
PV	Photovoltaic
R&D	Research and Development
RRC	Resource-Rich Countries
RREs	Rare Earth Elements
SADC	Southern African Development Community
SIPA	School of International and Public Affairs
SEZs	Special Economic Zones
SMEs	Small and Medium-sized Enterprises
UNCTAD	UN Trade and Development
UNECA	United Nations Economic Commission for Africa
UNIDO	United Nations Industrial Development Organization
WITS	World Integrated Trade Solution
ZDA	Zambia Development Agency

Executive Summary

This report examines how industrial policies shape economic diversification in developing economies within energy transition value chains, drawing on existing literature, interviews with experts, and multiple case studies.

Economic diversification is crucial for long-term sustainable growth and industrialisation. Both policymakers and researchers increasingly view it as a policy priority, recognising its role in shaping the long-term performance of developing economies. By broadening the range of productive activities and sectors within a country, diversification serves as a mechanism for sustaining economic expansion and improving living standards. This process is particularly important for developing economies, where a more varied economic base not only strengthens their resilience to external shocks and volatility but also opens up new avenues for innovation, attracts investment, and generates employment opportunities, thereby laying the foundation for more inclusive and durable development.[1]

Despite the recognised importance of diversification, many resource-rich countries (RRC) in Southern Africa often remain trapped in low-value raw material exports. This report, produced as part of a joint applied research project (ARP) with the Geneva Graduate Institute (IHEID), the UN Trade and Development (UNCTAD) and the Geneva Platform for Resilient Value Chains (GPRVC), examines how Namibia, Zambia, and Madagascar can leverage the global demand for critical energy transition minerals (CETMs) to catalyse industrial development in the solar photovoltaic (PV) and wind sectors, to pursue a diversification strategy.

In the context of this project, industrial policy emerges as the central lever for turning mineral endowments into broader economic diversification. Its role extends far beyond traditional manufacturing subsidies. Instead, it serves as a vital tool to create and coordinate new markets and strategically provide essential public inputs – such as tailored infrastructure, workforce education, and

[1]Corinne Deléchat, Giovanni Melina, Monique Newiak, Chris Papageorgiou, and Nikola Spatafora, Economic Diversification in Developing Countries: Lessons from Country Experiences with Broad-Based and Industrial Policies, Departmental Paper No. DP/2024/006 International Monetary Fund, July 2024), https://www.imf.org/-/media/files/publications/dp/2024/english/eddpea.pdf.

technology. Ultimately, industrial policy acts as the bridge that transforms raw mineral wealth into resilient economic growth by strategically accumulating domestic capabilities.

We conclude by recommending Namibia, Zambia, and Madagascar to follow these six strategic points to foster value addition through industrial policies:

I. Build capabilities gradually through adjacent industries rather than leaping directly into highly complex manufacturing;
II. Prioritise adaptive implementation by moving beyond initial policy design to a sustained focus on active implementation, monitoring, and evaluation;
III. Align with broader development goals, do not pursue industrialisation in a vacuum;
IV. Leverage regional integration to overcome small domestic markets;
V. Establish autonomous institutions to shield agencies from short-term political pressures;
VI. Commit to social and ecological sustainability.

** The findings, interpretations and conclusions expressed herein are those of the author(s) and do not necessarily reflect the views of the United Nations or its officials or Member States.*

1. Introduction: Project Overview and Key Concepts

Economic diversification and complexity are essential for long-term sustainable growth. Countries that manufacture more complex goods – meaning those requiring advanced skills, knowledge, and technology – tend to be more resilient and experience faster growth, in the long run.[2] For many developing countries, particularly those dependent on raw material exports,[3] economic diversification is presented as a key strategy for structural transformation and reducing vulnerability to external shocks.[4]

For Southern Africa, this need for transformation coincides with a rise in global demand for CETMs.[5] Over the past two decades, annual trade in CETMs has risen from $53 billion to $378 billion.[6] These minerals, such as copper, cobalt, nickel, lithium, and rare earth elements (REEs), are essential for the manufacture of clean energy technologies, including solar panels, wind turbines, and storage batteries.[7] Yet, despite this rapidly growing global demand[8] and the opportunities it creates, many RRC in Southern Africa remain heavily dependent on raw material extraction and export, with limited participation in higher-value manufacturing and services.[9] As a result, according to a 2023

[2] United Nations Conference on Trade and Development (UNCTAD), "Critical Energy Transition Minerals: Rapid Assessment of Value Addition and Diversification Capacity in Southern Africa," accessed March 30, 2026, https://unctad.org/project/critical-energy-transition-minerals-in-southern-africa.

[3] A country is considered to be commodity export dependent when more than 60 per cent of its total merchandise exports are composed of commodities. United Nations Conference on Trade and Development (UNCTAD), "The State of Commodity Dependence," accessed March 30, 2026, https://unctad.org/topic/commodities/state-of-commodity-dependence.

[4] UNCTAD, "Critical Energy Transition Minerals: Rapid Assessment of Value Addition and Diversification Capacity in Southern Africa; Deléchat et al., *Economic Diversification in Developing Countries*, 4.

[5] World Economic Forum, "Africa's Critical Minerals Could Power the Energy Transition – Here's How to Get It Right," April 2026, https://www.weforum.org/stories/2026/04/africa-critical-minerals-energy-transition/.

[6] Markos Farag and Chahir Zaki, "Allies and Enemies: On the Political Determinants of Trade in Critical Minerals," SSRN Working Paper, April 18, 2025, https://doi.org/10.2139/ssrn.5237987.

[7] International Energy Agency, "Mineral Requirements for Clean Energy Transitions," in *The Role of Critical Minerals in Clean Energy Transitions* (IEA, 2021), https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions/mineral-requirements-for-clean-energy-transitions.

[8]International Energy Agency. *Renewables 2025*. International Energy Agency, 2025. https://www.iea.org/reports/renewables-2025. By 2030, global renewable power capacity is set to grow by about 4 600 GW, twice as much as in 2019-2024. Solar PV drives nearly 80% of this increase, thanks to low costs, supportive policies, and social acceptance. Distributed solar (on homes, businesses, industry, and off-grid) makes up 42% of new PV capacity, boosted by high retail electricity prices and the need for reliable supply in countries with unstable grids (e.g., South Africa, Pakistan). Onshore wind additions in 2025-2030 are expected to be 45% higher than in 2019-2024, reaching 732 GW, as many countries ease permitting and grid barriers despite supply chain and inflation challenges. Offshore wind capacity is projected to reach 140 GW over 2025-2030, more than double the previous five-year period.

[9] United Nations Conference on Trade and Development (UNCTAD), "Critical Minerals Boom: Global Energy Shift Brings Opportunities and Risks for Developing Countries," April 26, 2024, https://unctad.org/news/critical-minerals-boom-global-energy-shift-brings-opportunities-and-risks-developing-countries; United Nations Conference on Trade and Development (UNCTAD), "Ministers Urge Global Partnership to Make Critical Minerals Work for Development," October 22, 2025, https://unctad.org/news/ministers-urge-global-partnership-make-critical-minerals-work-development.

World Bank report,[10] these countries capture on average only about 40 per cent of the potential revenues they could collect from these natural resources.[11]

Against this backdrop, UNCTAD has launched a project funded by the Government of Japan to help Southern African countries capture more value from CETM-related value chains.[12] It draws on economic complexity and product space analysis, building on trade data to provide a more accurate picture of domestic production and inform evidence-based policymaking. Given their endowments and production of key CETMs, Namibia, Zambia, and Madagascar are well-positioned to benefit from this project.[13]

This report examines how these three countries can move further along CETM-related value chains, with a focus on solar PV and wind sectors, and capture greater value addition by developing industrial policies that support diversification. Its central question is not whether these countries can develop full renewable energy manufacturing systems, but where along the value chain they can realistically build capabilities, create jobs, and strengthen long-term industrial development.

To address this question, the report follows a structured methodology. The starting point is an analysis of products involved in the solar and wind sectors using the Harmonised System (HS) classification.[14] This serves to map the value chains at the product level and identify specific goods with the greatest potential for export growth, value addition, and diversification. From this foundation, the report reviews existing data-driven tools on economic complexity available to developing countries, to assess their industrial capabilities and growth opportunities, with particular attention to

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[10] James Cust and Albert G. Zeufack, *Africa's Resource Future: Harnessing Natural Resources for Economic Transformation during the Low-Carbon Transition*, Africa Development Forum (World Bank, 2023), https://doi.org/10.1596/978-1-4648-1743-4.

[11] World Economic Forum, "Africa's Critical Minerals Could Power the Energy Transition – Here's How to Get It Right," April 2026, https://www.weforum.org/stories/2026/04/africa-critical-minerals-energy-transition/.

[12] United Nations Conference on Trade and Development (UNCTAD), "UN Trade and Development and Japan Partner to Add Value to Africa's Critical Minerals Sector," May 16, 2025, https://unctad.org/news/un-trade-and-development-and-japan-partner-add-value-africas-critical-minerals-sector.

[13] UNCTAD, "Critical Energy Transition Minerals: Rapid Assessment of Value Addition and Diversification Capacity in Southern Africa

[14] The Harmonized Commodity Description and Coding System, also known as the Harmonized System (HS), is an international multipurpose product nomenclature elaborated under the auspices of the World Customs Organization (WCO). The HS is governed by "The International Convention on the Harmoindustrialnized Commodity Description and Coding System", which was adopted in June 1983 and entered into force January 1988. It comprises more than 5,000 commodity groups; each identified by a six-digit code, arranged in a legal and logical structure and is supported by well-defined rules to achieve uniform classification. It serves as the foundation for the import and export classification systems. Over 98 per cent of the merchandise in international trade is classified in terms of the HS.

the UNCTAD model, which is the analytical framework adopted in this project. The report then includes a conceptual framework on industrial policy, providing the theoretical and empirical basis for the policy recommendations that follow. Expert interviews were conducted to further ground these recommendations and broaden the understanding of industrial policy frameworks as they apply to the three countries. Specifically, we interviewed four experts: Oliver Braunschweig, Industrial Policy Consultant at GPRVC; Clovis Freire, Chief Extractive Commodities Section at UNCTAD; Tom Moerenhout, Research Scholar at the Center on Global Energy Policy at Columbia University and Adjunct Associate Professor at the School of International and Public Affairs (SIPA); and Oliver Maponga, Economic Affairs Officer at United Nations Economic Commission for Africa (UNECA). Finally, these steps conclude in a set of targeted policy options to guide each country toward greater participation in energy transition value chains.

For this study, the value chain is understood as the sequence of activities required for the production of a particular good or service, from raw materials extraction to final assembly and deployment.[15] The report distinguishes between upstream, midstream, and downstream segments of value chains to identify where domestic capabilities could be strengthened and where industrial policies may be most effective. This framework is especially useful for Namibia, Zambia, and Madagascar, where the challenge is to connect resource endowments and trade potential with practical and efficient industrial strategies.

Three main concepts guide the analysis. First, economic diversification is defined as the transition from dependence on a narrow set of exports by developing multiple income sources across a broader range of sectors and markets.[16] Second, economic complexity, which measures a country's knowledge intensity by assessing the diversity and sophistication of its exports, productive capabilities, and development levels. This can be quantified through the Economic Complexity Index (ECI), inferred from data connecting locations to the activities that are present in them.[17] Countries that export a wide

[15] BloombergNEF, "How the Energy Transition Is Rewiring Global Trade: 2050 Scenarios," February 13, 2026, https://about.bnef.com/insights/clean-energy/how-the-energy-transition-is-rewiring-global-trade-2050-scenarios/.
[16] United Nations Framework Convention on Climate Change (UNFCCC), "Economic Diversification," accessed March 30, 2026, https://unfccc.int/topics/resilience/resources/economic-diversification.
[17] The Observatory of Economic Complexity, "Methods," accessed May 3, 2026, https://oec.world/en/resources/methods#eci.

variety of goods requiring advanced know-how score highly, while those relying on a few simple commodities score lower. Third, there is the concept of the product space, a framework that maps how closely related different products are to one another. Its central insight is that of relatedness: countries are more likely to diversify by moving into nearby products that require similar skills, knowledge, or infrastructure to what they already produce. The product space, therefore, is helpful for countries to define paths for diversification, based on the connectedness of their know-how.[18] In this report, these concepts are applied to energy transition value chains to assess which stages may offer the best opportunities for value addition, given each country's resources, infrastructure, and industrial base.[19]

The report is structured as follows. Section 2 establishes the study's context by presenting a profile of the three countries and analyzing solar and wind value chains based on HS code classifications. These are complemented by two appendices and an annex at the end of the report. Section 3 reviews data-driven tools related to economic complexity available for application in developing countries and beyond. Section 4 provides conceptual foundations. Section 5 assesses policy options and presents the main findings for each of the three countries, drawing on expert interviews. Section 6 concludes the report, providing strategic recommendations.

2. Context

The energy transition is substantially reshaping industrial opportunities and global trade patterns. Although clean energy products currently represent just 2.2 per cent of total international goods trade, this share is expected to grow as the transition gathers momentum. This trend is already underway, as investments in low-carbon assets reached a record US$2.3 trillion last year (up 8 per cent from 2024).[20] Yet, these benefits remain unevenly distributed: developing countries face distinct challenges and opportunities shaped by consideration of equity, security, sustainability, geography, governance, and access to global finance, creating a gap in transition capacities.[21] Because of this disparity,

[18] Harvard Growth Lab, "Product Space," *Atlas of Economic Complexity*, accessed May 3, 2026, https://atlas.hks.harvard.edu/countries/392/product-space.
[19] Hidalgo and Hausmann. 'The Building Blocks of Economic Complexity'. 10570
[20] World Economic Forum, *Fostering Effective Energy Transition 2025*, Insight Report (2025), https://www.weforum.org/publications/fostering-effective-energy-transition-2025/in-full/redefining-global-energy-systems/.
[21] Eliakira Kisetu Nassary et al., "Transitioning to Clean Energy and Opportunities for Developing Countries," *Energy Strategy Reviews* 62 (2025): 101909, 1, https://doi.org/10.1016/j.esr.2025.101909; World Economic Forum, Fostering Effective Energy Transition 2025, 39.

countries cannot rely on generic approaches; necessitating instead locally tailored industrial policies and globally aligned action that reflect their specific development priorities, institutional constraints, and opportunities for value addition.[22]

Namibia, Zambia, and Madagascar exemplify this tension. Each possesses substantial renewable energy potential accompanied by local critical mineral deposits essential for solar PV and wind technologies, yet all struggle with energy poverty, inadequate infrastructure, and economic concentration in raw material exports.[23] Industrial policies targeting value addition must therefore balance CETMs value chains opportunities against pressing needs, like enhancing manufacturing capacity, expanding electricity access – below 57 per cent across the three in 2023[24] – and strengthening food security, where agriculture employs most of the workforce but suffers chronic vulnerability to drought and climate shocks.[25] The following country profiles establish the baseline conditions, such as resources, infrastructure gaps, and industrial capabilities, that will frame subsequent analysis of value chain opportunities and policy options. For further detail, refer to Appendix A of this report.

2.1 Overview of the Three Countries

The following tables summarise the content of Appendix A. They represent country profiles for Namibia, Zambia, and Madagascar.

Table 1. Profile of Namibia

ECONOMIC INDICATORS	
GDP (2024)	US$13.4 billion

[22] Ibid.
[23] Alex-Oke, Temidayo, Olusola Bamisile, Dongsheng Cai, Humphrey Adun, Chiagoziem Chima Ukwuoma, Samaila Ado Tenebe, and Qi Huang. "Renewable Energy Market in Africa: Opportunities, Progress, Challenges, and Future Prospects." *Energy Strategy Reviews* 59 (2025): 101700. https://doi.org/10.1016/j.esr.2025.101700.
[24] World Bank, "Access to Electricity (% of Population)," *World Development Indicators*, accessed March 30, 2026, https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS; see Section 2.1 for country-specific data.
[25] C. S. Mutengwa, P. Mnkeni, and A. Kondwakwenda, "Climate-Smart Agriculture and Food Security in Southern Africa: A Review of the Vulnerability of Smallholder Agriculture and Food Security to Climate Change," *Sustainability* 15 (2023): 2882, https://doi.org/10.3390/su15042882.

GDP Global Rank	144th			
Economic Complexity (ECI)	89 / 130			
Income Status	Lower-middle			
TOP EXPORTS AND DESTINATIONS				
Products	Diamonds US$1.17bn	Uranium/thorium US$1.08bn	Radioactive chemicals US$847m	Gold US$821m
Markets	China US$1.83bn	South Africa US$1.25bn	Botswana US$973m	Belgium US$705m
SOCIAL AND INFRASTRUCTURE				
Population	3.2 million			
Urban Share	53.7%			
Electricity Access	56.7% (2023)			
Food Insecurity	~600,000 people			
Corruption (CPI)	46/100			
RENEWABLE ENERGY OPPORTUNITIES				
Solar Irradiation	2,700 kWh/m²/yr			
Wind Speed	>7 m/s · 1,700 km coastline			
Diversification Targets	Organic chemicals, iron/steel, machinery			

Table 2. Profile of Zambia

ECONOMIC INDICATORS	
GDP (2024)	US$25.3 billion
GDP Global Rank	117th
ECI	95/130
Income Status	Lower-middle

TOP EXPORTS AND DESTINATIONS				
Products	Raw copper US$7.44bn	Refined copper US$2.52bn	Nickel ore US$624m	Precious stones US$446m
Markets	Switzerland US$4.8bn	China US$2.96bn	India US$1.96bn	DRC US$1.2bn

SOCIAL AND INFRASTRUCTURE	
Population	22.5 million
Urban Share	47.4%
Electricty acess	51.1% (2023)
Food insecurity	~1.7 million people
Corruption	37/100
RENEWABLE ENERGY OPPORTUNITIES	
Solar irradiation	1,900–2,100 kWh/m²/yr
Wind speed	5.6–6.4 m/s
Diversification targets	Chemicals, machinery, food processing

Table 3. Profile of Madagascar

ECONOMIC INDICATORS	
GDP (2024)	US$17.4 billion
GDP Global Rank	134th
ECI	120/130
Income Status	Low

TOP EXPORTS AND DESTINATIONS				
Products	Raw Nickel US$482m	Vanilla US$273m	Cloves US$221m	Titanium Ore US$165m
Markets	United States US$593m	France US$566m	China US$283m	India US$206m
SOCIAL AND INFRASTRUCTURE				

Population	32.7 million
Urban share	32%
Electricty acess	39.4% (2023)
Food insecurity	1.57 million people
Corruption	25/100
Human Capital Index	0.39 (among lowest globally)
RENEWABLE ENERGY OPPORTUNITIES	
Solar irradiation	>2,000 kWh/m²/yr
Wind speed	>7 m/s
Diversification targets	Graphite electrodes, battery inputs

2.2 Harmonised System Codes Analysis

To identify concrete opportunities for value addition in CETM-related value chains, this report draws on a detailed analysis of HS codes using UNCTAD's data-driven tool (discussed in Section 3.2). On this basis, a comprehensive list of 6-digit HS codes relevant to solar PV and wind value chains has been compiled (see Annex A), together with product descriptions, core sector classification, and the specific scope of each product within the respective value chain stages. This list serves as the basis for mapping the structure of the value chains and for identifying where the three countries may have the greatest potential to participate in, or move further into, specific stages of production.

The HS codes analysis, which can be found in Appendix B, allows the report to move from a broad discussion of renewable energy sectors to a more precise product-level assessment. By distinguishing between different categories of goods and leveraging UNCTAD's results, the analysis allows the identification of the products that are already traded internationally, the ones that may offer export potential, and the ones that may support import substitution or local value addition in Namibia, Zambia, and Madagascar. The findings presented draw on a selected set of codes from Annex A that appear most relevant for the three countries. These are products with substantial export potential or import substitution opportunities that are also close to existing national capabilities. In other words, they are similar to goods already manufactured domestically, enabling realistic industrial upgrading within each country's current productive structure.

To better understand the analysis, it is important to first define the concepts of world weighted opportunity and import substitution. World weighted opportunity, or export potential, is understood here as a methodological approach that estimates the theoretical export value of a specific product from a source country to a target market. The export potential is weighted by key factors like supply capacity, demand, and ease of trade. It moves beyond simple past performance to identify where a country can realistically increase exports. Import substitution, instead, is conceptualised as an economic strategy aimed at promoting local industries by replacing imports with domestically produced goods.

3. Data-Driven Tools Landscape

Evidence-based industrial policy requires good information, but the question of which information, generated how, and interpreted through what framework, has become increasingly central as the ambition of industrial strategies has grown. To achieve sustainable national development, decision-making should be transparent, accountable, grounded in evidence, and strategically aligned with long-term objectives.[26] Advocating for this means relying on high-quality data and instruments to translate raw information into informed decisions.[27] Over the past two decades, a new generation of data-driven tools has emerged to help governments, international organisations, and development partners move beyond qualitative assessments toward more rigorous, evidence-based approaches to

[26] Iyabode Lawal, Comfort, Solomon Christopher Friday, Damilola Christiana Ayodeji, and Adedamola Sobowale. 'Strategic Framework for Transparent, Data-Driven Financial Decision-Making in Achieving Sustainable National Development Goals'. *International Journal of Advanced Multidisciplinary Research and Studies* 4, no. 6 (2024): 1655–78. https://doi.org/10.62225/2583049X.2024.4.6.4098.

[27] Ogwal, Jonathan, DevOps, and Global Voice Group. 'The Key Elements for Data-Driven Economic Growth'. Global Partnership for Sustainable Development Data, 1 October 2024. https://www.data4sdgs.org/blog/key-elements-data-driven-economic-growth.

diversification and value addition. As data itself becomes a central pillar of the economy,[28] the tools used to shape industrial strategy have become increasingly empirical. These tools – including economic complexity platforms, industrial policy diagnostics, composite indices, and trade databases – constitute a practical system that policymakers can draw on when designing strategies for productive transformation. Knowing which instrument is appropriate for which question is therefore helpful for designing strategies that are both ambitious and achievable.

This section provides an overview of the principal data-driven tools relevant to value chain analysis and industrial strategy, organised into four categories: economic complexity analysis tools, industrial policy tools, indices, and databases. The aim is twofold. First, to offer countries, development organisations, and other stakeholders a structured map of what exists and what is for; a resource that is frequently missing in policy conversations dominated by a small number of well-known platforms. Second, to situate the UNCTAD tool used as the primary analytical instrument in this report within that wider landscape, and to explain why its combination of highly disaggregated trade data, price-quality segmentation, and on-the-ground qualitative validation makes it the most appropriate choice for the specific context of this report.

3.1 Overview of Existing Data-Driven Tools

a. Economic Complexity Analysis Tools

The Clean Industrial Capabilities Explorer (CICE) has been developed by the Johns Hopkins Net Zero Industrial Policy Lab, whose mission is to "combine technical analysis of clean energy supply chains with the study of net-zero industrial policies and geopolitical dynamics."[29] It functions as a specialised analytical framework designed to map national industrial capabilities relative to the clean energy transition. Methodologically, the tool employs a random forest machine learning model trained on competitiveness and global trade data from 2003 to 2023, on 10 clean energy technologies (solar, wind, batteries, electrolysers, heat pumps, permanent magnets, nuclear, biofuels, non-drilling

[28] Ciuriak, Dan. "Rethinking Industrial Policy for the Data-driven provideprovideEconomy." CIGI Papers No. 192. Centre for International Governance Innovation, 2018. https://www.cigionline.org/static/documents/documents/Paper%20no.192web.pdf

[29] Net Zero Industrial Policy Lab. 'The Clean Industrial Capabilities Explorer'. The Clean Industrial Capabilities Explorer. Accessed 6 April 2026. https://cice.netzeropolicylab.com/.

geothermal, and transmission). CICE's results provide empirical foundations for understanding where countries are best positioned within clean energy value chains to develop sustainable industrial strategies.

The UNCTAD Economic Complexity Model provides a comprehensive framework for analysing structural economic transformation, specifically tailored to assist nations in identifying adjacent product diversification pathways based on their existing production capacities.[30] Section 3.2 provides an in-depth description of this tool.

The Harvard Atlas of Economic Complexity is a data visualisation tool that "allows people to explore global trade flows across markets, track these dynamics over time and discover new growth opportunities for every country."[31] Practically, it serves to analyse a country's existing export/import portfolio and identify new growth opportunities where they have a competitive edge.

b. Industrial Policy Tools

The New Industrial Policy Observatory (NIPO) has emerged in response to governments' needs to confront digital and energy transitions, supply-chain vulnerabilities, and intensifying geopolitical risks. As a partnership between Global Trade Alert and the International Monetary Fund (IMF), it is a policy-level monitoring tool designed to track global state interventions that shape market competition, by mapping firm- and sector-specific actions, and enabling users to assess financial scale, trade exposure, and supply-chain vulnerabilities in strategic sectors like semiconductors, critical minerals, and low-carbon technologies. It aims to help "monitor the evolution and effects of industrial policies.[32]

The United Nations Industrial Development Organization (UNIDO)'s Industrial Analytics Platform (IAP) is an "innovative tool providing data on select indicators of industrial development

[30] Freire, Clovis, and Sofia Dominguez. *Strategic Diversification: Empirical Insights for Leveraging Economic Complexity to Break Free from Commodity Dependence*. UNCTAD, 2026. https://unctad.org/system/files/official-document/wp-2026d2_en.pdf.

[31] Harvard Growth Lab. 'Atlas of Economic Complexity'. Atlas of Economic Complexity. Accessed 6 April 2026. https://atlas.hks.harvard.edu.

[32] Evenett, Simon, Adam Jakubik, Fernando Martín, and Michele Ruta. 'The Return of Industrial Policy in Data'. *The World Economy* 47, no. 7 (2024): 2762–88. https://doi.org/10.1111/twec.13608.

and relevant research by leading experts in an accessible format."[33] It mainly serves as a centralised hub aggregating empirical data, visualisations, and analytical literature on global manufacturing trends and structural changes, by contextualising national industrial trajectories within macro-level global manufacturing shifts. Doing so, the IAP focuses on four different themes: industrial development, manufacturing performance, competitiveness, and global value chains.

The UNIDO's Enhancing the Quality of Industrial Policies (EQuIP) framework is designed to facilitate the formulation of evidence-based industrial strategies, to navigate through "ever-changing global dynamics."[34] The EQuIP toolkit aims to enhance the quality of industrial policies by providing policymakers with evidence-based diagnostic tools to produce country- and time-specific industrial policies. It is designed to support sustainable industrial development by evaluating performance across three core dimensions, namely economic, social, and environmental, to empirically highlight strengths and weaknesses of industrial sectors.

The Policy Capacity Gap Analysis by UNIDO is a diagnostic tool that provides countries with their "strengths and weaknesses in the capacities needed for evidence-based industrial policymaking, including analytical, operational, and political skills at the individual, institutional, and ecosystem levels."[35] By identifying specific gaps within the policy space of each country, UNIDO designs capacity development programmes and strengthens "overall policy effectiveness."

The Chain Analysis Tool by UNIDO is an Excel-based framework that converts raw data into dynamic visual formats. It offers a structured methodology to "facilitate the visualisation and study of costs and profit margins along value chains." The tool can be applied to all phases of any project to "improve chain management, diagnose current and future economic scenarios, develop action plans, evaluate impacts, and monitor trends."[36]

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[33] UNIDO. 'Industrial Analytics Platform (IAP)'. Industrial Analytics Platform. Accessed 6 April 2026. https://iap.unido.org/about.

[34] UNIDO. 'EQuIP Project'. UNIDO. Accessed 6 April 2026. https://www.unido.org/learning-resources/equip-project.

[35] UNIDO. 'Industrial Policy Advice and Capacity Development'. UNIDO. Accessed 6 April 2026. https://www.unido.org/industrial-policy-advice-and-capacity-development/our-policy-tools.

[36] UNIDO. 'Chain Analysis Tool (CAT): A Tool for Cost Structure and Profit Margin Analysis along Value Chains'. UNIDO. Accessed 6 April 2026. https://www.unido.org/learning-resources/chain-analysis-tool-cat-tool-cost-structure-and-profit-margin-analysis-along-value-chains.

c. Indices

Harvard's Greenplexity Index acts as a country ranking, and aims to capture countries' presence in green value chains, based on the "breadth and complexity of its industries,"[37] showing how many capabilities a country has in the industries driving the energy transition, enabling policymakers to identify opportunities across global energy transition value chains. Derived from the economic complexity framework developed by the Growth Lab, the Index focuses on productive capabilities in industries related to the energy transition.

UNIDO's Competitive Industrial Performance helps assess national industrial performance in the global economy.[38] This index captures the ability of countries to produce and export competitively in a single measure.

d. Database & Dataset

Lastly, the list here presents databases and datasets related to economic complexity, trade, and value chains:

I. Economic Fitness (by World Bank): The Economic Fitness measures a country's level of diversification and its ability to produce complex goods on a globally competitive basis.[39]

II. Trade in Value-Added (by OECD): The Trade in Value-Added measures the addition of value (in financial terms) by each country in the production of goods and services that are consumed worldwide.[40]

III. Observatory of Economic Complexity (OEC): The OEC provides detailed global trade data, covering trade patterns, economic performance, and visualisations.[41]

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[37] Harvard Growth Lab. 'Harvard Growth Lab Unveils Greenplexity Index: New Country Rankings Reveal Global Leaders in Supplying the Energy Transition'. *Growth Lab*, n.d. Accessed 6 April 2026. https://growthlab.hks.harvard.edu/news/harvard-growth-lab-unveils-greenplexity-index/.

[38] 'Benchmarking Industrial Performance at the Country Level: The UNIDO Competitive Industrial Performance Index'. In *Industrial Development Report 2009*, by United Nations Industrial Development Organization. Industrial Development Report. UN, 2009. https://doi.org/10.18356/2b257349-en.

[39] World Bank Group. 'Economic Fitness - World Bank Data Catalog'. Accessed 6 April 2026. https://datacatalog.worldbank.org/search/dataset/0041694/economic-fitness.

[40] OECD. 'Trade in Value-Added'. OECD. Accessed 6 April 2026. https://www.oecd.org/en/tiva.html.

[41] OEC. 'The Observatory of Economic Complexity'. The Observatory of Economic Complexity. Accessed 6 April 2026. https://oec.world/en/.

IV. UN Comtrade Database: The Comtrade Database presents global trade data. It covers around 200 countries and accounts for over 99 per cent of global trade in goods.[42]

V. Trade Map (by International Trade Centre): Trade Map provides global trade data – in the form of tables, graphs, and maps – on export performance, international demand, alternative markets, and competitive markets[43].

VI. World Integrated Trade Solution (WITS) (by World Bank): WITS is a software that allows users to access and retrieve data on trade and tariffs globally[44].

VII. STAN (by OECD): The STAN Database, standing for STructural ANalysis, is a comprehensive tool for analysing industrial performance, and allowing users to construct a wide range of indicators and focus on areas such as productivity growth, competitiveness, and general structural change[45].

3.2 In-Depth Focus on the UNCTAD Tool

UNCTAD's data-driven tool can be considered a policy-oriented instrument. As explained by Clovis Freire, Chief of the Extractive Commodities Section in UNCTAD's Division on International Trade and Commodities, the tool is different from the others analysed above because it offers a policy-oriented adaptation of the economic complexity and product space frameworks. UNCTAD's tool goes beyond standard benchmarking to provide a more detailed, country-specific analysis. It does this by using a highly disaggregated dataset, processing 49,000 products from the UN Comtrade Database at a fine level of detail (HS 6-digit codes). The tool then groups these products into price–quality segments, based on the prices at which they are traded.[46]

This method allows UNCTAD to measure product complexity, map which products each country currently exports, and how these are connected to others that the country could potentially export, including different price and quality ranges, overcoming the visual limitations of less detailed models

[42] United Nations Statistic Divisions. 'UN Comtrade'. Accessed 6 April 2026. https://comtradeplus.un.org/.
[43] ITC. 'Trade Map - Trade Statistics for International Business Development'. Accessed 6 April 2026. https://www.trademap.org/Index.aspx.
[44] World Bank. 'WITS - About WITS'. Accessed 6 April 2026. https://wits.worldbank.org/about_wits.html.
[45] OECD. 'Structural Analysis Database'. OECD. Accessed 6 April 2026. https://www.oecd.org/en/data/datasets/structural-analysis-database.html.
[46] Clovis Freire, interview by the authors, March 19, 2026.

based on HS 4-digit codes. Moreover, UNCTAD adjusts standard measures for diversification and ubiquity. These refinements help to better capture the volatility of small commodities and to distinguish between products that may look similar but are sold at very different price and quality levels.

The quantitative analysis is then complemented by a qualitative component, consisting of interviews with governments and private sector actors directly on the ground. This approach allows UNCTAD to identify whether producing certain goods is technically and economically feasible, what kinds of investments would be needed, and specific barriers that prevent the production of certain goods in a particular country. This helps translate abstract complexity metrics into concrete, practical, and targeted recommendations for industrial policies that can support diversification, value addition, and resilient growth.

3.3 Discussion of the Data-Driven Tools Overview

From the Atlas of Economic Complexity and its product space visualisations, to foundational datasets like UN Comtrade and the OEC, each instrument captures a different dimension of a country's productive structure, trade potential, or institutional readiness. No single tool answers all questions, and the value of surveying the full landscape lies precisely in understanding those complementarities and boundaries.

Practically, a government seeking to identify export opportunities in a specific value chain needs a different tool than one conducting a broader audit of its policy implementation capacity. A development bank appraising a sectoral investment requires different data than a trade ministry designing a local content regulation. By making explicit what is available and what each tool is designed to do, this section equips stakeholders to ask better questions and to match their analytical needs to the right instruments; rather than defaulting to whichever platform is most visible or most familiar.

What the landscape as a whole reveals is a convergence around a common principle: that industrial upgrading must be grounded in a realistic assessment of existing capabilities, and that the distance between where a country is and where it wants to go must be accurately measured. It is against this backdrop that UNCTAD's tool earns its role as the central analytical instrument of this report. By processing approximately 49,000 HS 6-digit codes, disaggregating products by price-quality band, and validating statistical outputs through direct interviews with private sector actors and policymakers, it bridges the gap that most other tools leave open: between abstract complexity metrics and the concrete feasibility constraints facing decision-makers in Namibia, Zambia, and Madagascar.

The HS code findings in Section 2, and the industrial policy recommendations in Section 5, are therefore the product of an instrument specifically designed to translate productive structure data into actionable, country-specific guidance; the standard against which all tools in this landscape should ultimately be assessed.

4. Conceptual Foundations of Industrial Policy

This section draws on academic literature to establish the conceptual foundations for analysing industrial policy in the context of CETM value chains and developing RRC countries.

Industrial policy is widely understood as a government action to change or support the structure of the economy, promoting economic development while acting towards achieving a public goal, as defined by multiple authors, such as Juhász and Steinwender,[47] Lane,[48] and Rodrik.[49] Altenburg et al.[50] and Di Maio[51] converge in their understanding that industrial policy includes any type of government policy promoted through coordination among the state activities towards structural changes that would not have been promoted without this intervention.

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[47] Juhász, Réka, and Claudia Steinwender, "Industrial Policy and the Great Divergence," Annual Review of Economics 16 (2024): 30, https://doi.org/10.1146/annurev-economics-091523-044259.
[48] Nathaniel Lane, "The New Empirics of Industrial Policy," Journal of Industry, Competition and Trade 20, no. 2 (June 2020): 209–34, https://doi.org/10.1007/s10842-019-00323-2.
[49] Dani Rodrik, "Green Industrial Policy," *Oxford Review of Economic Policy* 30, no. 3 (Autumn 2014): 469–91, https://doi.org/10.1093/oxrep/gru025.
[50] Tilman Altenburg et al., *Industrial Policy: A Key Element of the Social and Ecological Market Economy* (Bonn: German Development Institute, 2008), 3, https://www.idos-research.de/uploads/media/Altenburg_et_al.__2008__Industrial_Policy_01.pdf.
[51] Michele Di Maio, "Industrial Policy," International Development Research Centre, s.d., 6, https://idl-bnc-idrc.dspacedirect.org/server/api/core/bitstreams/4f3c69d8-5b3a-4497-bd2b-2225dd039455/content.

Industrial policies have recently started to be understood as ways to shape markets to achieve specific outcomes, such as long-term environmental sustainability and the security of global value chains. With a modern view, OECD defines industrial policy as:

> government assistance to businesses to boost or reshape specific economic activities, especially to firms or types of firms based on their activity, technology, location, size or age. Governments use industrial policies to address important economic, social and environmental challenges that markets cannot address on their own, such as to accelerate the green transition, or improve the robustness of value chains for critical products and services.[52]

Industrial policies have been widely studied since Krueger and Tuncer's landmark analysis on Turkish import substitution industrialization – the first rigorous empirical assessment of how government imposition of high tariffs and subsidies to protect infant industries impacts them.[53] However, this work has also faced substantial criticism regarding the validity of its findings.[54] Economists have argued that it is often hard to precisely target and direct effective intervention.[55] Rodrik,[56] argues that this is not a particularity of industrial policies, but any policy can be inefficient if not well developed and implemented by the government. This is why we recognise the importance of analysing and comprehending the successes and failures of past policies, as well as research done based on those past cases. Moreover, designing industrial policies that contain informational and policy risks to address clear market imperfections, as argued by the economist Ernest Liu, could be a solution to target those issues, as we will argue in the upcoming paragraphs.[57]

It is also important to understand that industrial policy has historically focused on developing manufacturing and improving competitiveness, while modern conceptions reflect a broader scope. As Braunschweig observes, governments should not be primarily targeting manufacturing but, instead,

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52 Chiara Criscuolo et al., "An Industrial Policy Framework for OECD Countries: Old Debates, New Perspectives," OECD Science, Technology and Industry Policy Papers, no. 127 (2022): 8, https://doi.org/10.1787/0002217c-en.

53 Anne O. Krueger and Baran Tuncer, "An Empirical Test of the Infant Industry Argument," *The American Economic Review* 72, no. 5 (1982): 1142–52.

54 Lane, "New Empirics of Industrial Policy," 212.

55 Ibid.

56 Robert Armstrong and Ethan Wu, "Dani Rodrik: Doing Industrial Policy Right," Financial Times, February 9, 2024, https://www.ft.com/content/49969248-c92c-4614-8785-3e2889278772.

57 Ernest Liu, "Industrial Policies in Production Networks," The Quarterly Journal of Economics 134, no. 4 (November 2019): 1890, https://doi.org/10.1093/qje/qjz024.

creating and coordinating new markets or addressing existing market failures and providing activity-specific public inputs – such as infrastructure, education, healthcare, and technology – to strengthen resilience and national security.[58]

4.1 Industrial Policy for Value Addition

The modern landscape of industrial policy has seen a significant global resurgence, moving from the periphery of economic discourse back to the center of national strategies. According to data from the Global Trade Alert's NIPO, there has been a significant increase in industrial policy interventions since 2023, driven primarily by the world's largest economies (United States, the European Union, and China). This new policies differ from its predecessors as most of these interventions are now motivated by objectives beyond traditional competitiveness, such as the green energy transition, supply chain resilience, and national security.[59]

This global surge creates a competitive environment where policy-induced advantages are becoming more frequent. For instance, high-income countries account for the majority of those new policies, as NIPO data reveals, which makes it even more difficult for low- and middle-income countries to navigate amidst these global races.

Nevertheless, Braunschweig highlights several key characteristics of effective industrial policies: they should be grounded in transparent, ongoing consultation with the private sector and civil society; address clearly defined market failures; be consistent with other policy areas; have a clearly defined endpoint; and remain credible throughout the entire policy process.[60]

Successful industrial policies must be grounded in local needs. Transplanting policies from one context to another, or from one sector to the next, inherently produces divergent outcomes. This is exemplified by Indonesia's experience with export restrictions and lower import tariffs as a way of attracting foreign investment in its domestic nickel and bauxite industries. The same policy yielded positive results for the nickel sector but severely damaged the bauxite industry. This case highlights

[58] Oliver Braunschweig, interview by the authors, March 31, 2026.
[59] Evenett et al., "Return of Industrial Policy in Data," 2765.
[60] Braunschweig, interview.

the importance of going beyond general theories and empirical evidence to develop tailored scenarios and a deep understanding of the specific context of each sector.

To navigate these specificities, it is important to rethink the excessive focus given on the design phase, as argued by Freire.[61] Braunshweig suggests a framework in which implementation, monitoring, evaluation, and adjustments receive a greater emphasis than policy design itself. According to the expert, this requires three distinct and interlocking parts, where information flows between all three. First, policymakers must clearly identify market failures and design solutions that respond to existing circumstances and goals. Second, the implementation phase should follow institutional design and be accompanied by systematic monitoring. Third, insights from the implementation must generate feedback to policymakers through a transparent and democratic process, which should be used by those monitoring and evaluating, as well as by policymakers, to ensure adaptation according to the given circumstances. Moreover, effective industrial policies require continuous analysis conducted in close collaboration with the private sector.[62] Indeed, while government agencies can shape markets through strategic investments, long-term commitments, and coherent policy frameworks, markets ultimately emerge from the interactions between public and private actors, as well as civil society.[63] Consequently, designing an industrial policy that is applicable in practice requires maintaining an ongoing, structured dialogue among all these actors.

Policies are often carefully designed, yet frictions, technological change, and geopolitical developments can directly alter their original trajectory. The theory of the second-best solution, developed by the economists Lipsey and Lancaster,[64] highlights that while mainstream economic theory targets a Pareto optimum, most real-world markets are marked by multiple inefficiencies. The core problem identified by this theory is that when such inefficiencies exist, it is not clear that removing a single source of market friction necessarily leads to a better market outcome.[65] According

[61] Clovis Freire, interview by the authors, March 19, 2026.
[62] Ibid.
[63] Mariana Mazzucato, "Mission-Oriented Innovation Policy in the European Union," *European Commission* (February 2018): 5, https://ec.europa.eu/info/sites/default/files/m_mazzucato_report_2018.pdf.
[64] R. G. Lipsey and Kelvin Lancaster, "The General Theory of Second Best," *The Review of Economic Studies* 24, no. 1 (1956): 11, https://doi.org/10.2307/2296233.
[65] Ibid.

to this theory, leaving certain frictions in place or even introducing new ones could, at least in theory, improve overall welfare. While Lipsey notes that this theory does not justify extreme market distortions, it suggests that “carefully designed, administered, and sunsetted” industrial policies can serve as an adequate solution to market failures.[66] If this theory holds, policymakers should seek pragmatic, targeted interventions rather than relying on the removal of single distortions in isolation, building in flexibility to address real-world frictions.[67]

Therefore, industrial policies should consider informational and policy risks.[68] Following Peter Evans concept of embedded autonomy,[69] it is important to create an institutional design in which agencies responsible for industrial policies are shielded from short-term political cycles and undue influence (autonomy), but remain deeply open to learning and receiving feedback from the private sector and civil society (embeddedness). This structure enables governments to ensure that the policy remains nimble enough to solve the underlying market failures it was designed to address, even when faced with the second-best realities of operating in a complex global market.

4.2 Key Challenges in Designing and Implementing Industrial Policy

Zambia, Namibia, and Madagascar face significant structural challenges in designing and implementing industrial policies capable of moving their economies beyond raw material exports. This report identifies three principal categories of obstacles: the enclave trap created by foreign direct investment (FDI), institutional and financial frictions, and the broader challenge of achieving policy coherence and governance.

The implementation of industrial policies in commodity-dependent countries often faces a significant hurdle regarding FDI because, without proper management, such investments can lead to a “low-value-addition trap.”[70] Since these countries are rich in minerals, FDI tends to concentrate in raw material extraction rather than processing, leading to a cycle of reliance on raw material extraction

[66] Richard G. Lipsey, "Reflections on the General Theory of Second Best at its Golden Jubilee," International Tax and Public Finance 14, no. 4 (August 2007): 349–64, https://doi.org/10.1007/s10797-007-9036-x.
[67] Lipsey and Lancaster, "General Theory of Second Best," 11.
[68] Dani Rodrik, "Green Industrial Policy," Oxford Review of Economic Policy 30, no. 3 (Autumn 2014): 469–91, https://doi.org/10.1093/oxrep/gru025.
[69] Peter Evans, Embedded Autonomy: States and Industrial Transformation (Princeton University Press, 1995), 12.
[70] Tom Moerenhout, interview by the authors, March 24, 2026.

without value addition, as Freire Junior and Dominguez (2026) found.[71] Moreover, foreign companies often bring their own technical staff, leaving the domestic workforce with only low-skilled jobs, as argued by Hausmann et all (2013).[72] Without a concerted effort to invest in skills development and domestic technical capabilities, these countries will struggle to move into products that are more complex than their current exports.

According to Evans, achieving policy coherence requires building institutions that are aligned with existing policies and goals, shielded from undue influence, and open to feedback from multiple sources.[73] For industrial policy to work in the three analysed countries, it must navigate a complex landscape where political elites prioritise short-term earnings over long-term structural change. Furthermore, community development agreements are often missing or weak; without inclusive dialogue between the private sector, government, and local communities, mining and processing activities fail to provide transferable skills or lasting infrastructure and make local protests more likely. This lack of a broad perspective on innovation, one that includes social and geopolitical contexts, means that when a mineral cycle ends, the local economy is often left without the resilience or the diversified base needed to sustain growth or sustainable governance. It is often the case that local populations are left with environmentally degraded landscapes and toxic waste, which are extremely expensive to regenerate and manage, respectively.

4.3 Enabling Factors and Good Practices

Moving beyond theoretical design and ensuring that an industrial policy functions effectively in practice requires specific enabling factors that foster long-term resilience.[74] A critical enabling factor is the development of a broad system of innovation. As argued by the economist Mazzucato innovation policy is not just about funding R&D, it involves creating systems that allow new knowledge to be diffused across an entire economy to drive transformative change and productivity

[71] Freire and Dominguez, Strategic Diversification, 15.
[72] Ricardo Hausmann et al., *The Atlas of Economic Complexity: Mapping Paths to Prosperity* (Cambridge, MA: MIT Press, 2013), 18–22, https://atlas.cid.harvard.edu/library.
[73] Peter Evans, Embedded Autonomy: States and Industrial Transformation, 12.
[74] Zuzana Zavarská et al., Toward Innovation-Driven Growth: Innovation Systems and Policies in EU Member States of Central Eastern Europe, Research Report 476 (Vienna: The Vienna Institute for International Economic Studies, 2024), https://wiiw.ac.at/toward-innovation-driven-growth-innovation-systems-and-policies-in-eu-member-states-of-central-eastern-europe-dlp-6998.pdf

increases.[75] According to Cassiolato[76] and recent assessments by Zavarská *et al.*, this requires a broad perspective on innovation that integrates two sets of interventions.[77] The first consists of a subset of policies focused on human capital, and on science and technology, such as capacity-building, training, and formal education. However, these measures are insufficient if applied in isolation. They should be embedded with broader subsystems, including strategic governance, finance, and the geopolitical and socio-economic context. Thus, the first subset, building domestic capabilities, should dialogue with the second, that is, creating the structural conditions to absorb and deploy those capabilities.

Freire and Dominguez (2026) point out that many RRCs fall into the trap of allowing foreign companies to transfer technology in ways that create only low-skilled jobs for local workers, while the higher value-added activities are carried out by foreign employees and primarily benefit foreign firms.[78] To avoid this, a country should prioritise developing its own capabilities and investing in increasing local skills[79] in strategic ways. As global markets in renewable energy are already dominated by big economies, it would be interesting for smaller economies to start by investing in less complex components, as argued by Yeung and Coe.[80]

In the solar sector, for instance, an RRC might not initially be able to produce entire wafers, but it could negotiate with major players, such as China, to manufacture smaller and less complex components, as defended by Currier *et al*.[81] It is also important to search for and cooperate with allies in regional markets. This strategy increases the chances of securing a position in the market and protecting domestic producers, while the country gradually builds the technical capacity needed to move further downstream, namely strategic coupling.

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[75] Mazzucato, Mission-Oriented Innovation Policy, 7.
[76] José E. Cassiolato, "Evolution and Dynamics of the Brazilian National System of Innovation," in Emerging Economies: Food and Energy Security, and Technology and Innovation, ed. Parthasarathi Shome and Praveen Sharma (Springer, 2015), 265–310.
[77] Zavarská et al., Toward Innovation-Driven Growth, 22.
[78] Freire and Dominguez, *Strategic Diversification*, 15.
[79] Ibid.
[80] Henry Wai‑chung Yeung and Neil M. Coe, "Toward a Dynamic Theory of Global Production Networks," *Economic Geography* 91, no. 1 (January 2014): 48, https://doi.org/10.1111/ecge.12063.
[81] Sophie Currier, Chunping Xie e Jingwen Guo, *China's Role in Accelerating the Global Energy Transition through Green Supply Chains and Trade* (Londres: Grantham Research Institute / LSE, 2024), 22-25, https://www.lse.ac.uk/granthaminstitute/wp-content/uploads/2024/02/Chinas-role-in-accelerating-the-global-energy-transition-through-green-supply-chains-and-trade.pdf.

Building these capabilities often requires a technological push to integrate digital technologies into the production process. The economist Carlota Perez[82] observes that we are currently in a new technological revolution of Artificial Intelligence, and developing countries need to enter this cycle at the beginning rather than the end. Since technological, social, and institutional changes occur in pieces, countries must align their production patterns with new consumption and digital infrastructure.

Furthermore, industrial policy must prioritise food security as a foundational element of infrastructure and social stability.[83] As Athukorala and Crowley highlight, this can be demonstrated in Malaysia's strategy,[84] where the government utilized the Federal Land Development Authority (FELDA) to stabilize the rural economy through palm oil and rubber production while simultaneously subsidizing paddy farming to ensure domestic rice price stability.[85] According to Shereen Shariff et al., treating the agricultural sector as a stabilizer instead of a legacy industry allowed Malaysia to prevent the urban bias that often leads to social turbulence in rapidly industrializing nations.[86]

The experience of Malaysia demonstrates that food security is a prerequisite for broader industrial success; without a stable and nourished population, the social frictions resulting from food shortages can derail long-term industrial goals. Freire notes that identifying which sectors are most impactful politically and ensuring they facilitate earnings for the people is a necessary part of navigating the political economy.[87] This means prioritising sectors, like agriculture, that offer domestic stability while building the groundwork for more complex industrial transitions.

Ultimately, overcoming structural and institutional hurdles requires a shift from static, over-ambitious plans to a dynamic, grounded implementation framework. To escape the raw-material dependency, Zambia, Namibia, and Madagascar must prioritise the internal accumulation of technical

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[82] Carlota Perez, Technological Revolutions and Financial Capital: The Dynamics of Bubbles and Golden Ages (Edward Elgar Publishing, 2002), 45.
[83] Ibid.
[84] Prema-chandra Athukorala, Distortions to Agricultural Incentives in Malaysia, Agricultural Distortions Working Paper 45 (Washington, DC: World Bank, 2017), 2, https://documents1.worldbank.org/curated/en/529711468339904250/pdf/560760NWP0MY0v1IC10Malaysia10308rev.pdf.
[85] Maura Crowley, "Foreign Labor Shortages in the Malaysian Palm Oil Industry: Impacts and Recommendations," *Asian Journal of Agriculture and Development* 17, no. 2 (2020): 6, https://doi.org/10.37801/ajad2020.17.2.1.
[86] Shereen Shariff et al., "Towards Achieving of Long-Term Agriculture Sustainability: A Systematic Review of Asian Farmers' Modern Technology Farming Behavioural Intention and Adoption's Key Indicators," International Journal of Professional Business Review 7, no. 6 (2022): e01130, https://doi.org/10.26668/businessreview/2022.v7i6.1130.
[87] Freire, interview.

capabilities and regional cooperation. By achieving embedded autonomy[88] and ensuring that industrial goals are aligned with the political and community interests, these nations can build the resilience necessary to transform mineral wealth into sustainable, diversified growth.[89] This transition is not merely a technical challenge of infrastructure or finance, but a strategic necessity to ensure that the global energy transition serves as a catalyst for long-term domestic prosperity rather than another cycle of extraction without generating development.

Industrial policy for value addition is not a linear path, but a complex, integrated cycle. Successful outcomes depend on reimagining the way industrial policy is built and implemented. It requires shifting focus from static initial design to understanding that industrial policy must be continuously reviewed and adapted according to monitoring and evaluation results. Individualising policies to address the idiosyncratic market-specificities of each sector allows governments to avoid misleading one-size-fits-all strategies. Ultimately, the success of economic diversification policies depends on creating and nurturing democratic institutions that empower the private sector, civil society, academia, and local communities to identify problems and propose solutions to address or prevent them. This approach is essential for giving industrial policy frameworks the best chance of remaining nimble in addressing market failures. At the same time, it must build in prudent hedging so that these frameworks stay flexible and can adapt to an ever-changing global market.

5. Assessment of Industrial Policy

In this report, we understand effective industrial policy as emerging from continuous negotiation between developmental ambitions and real-world constraints. Against this backdrop, this section synthesises consultation outcomes with four experienced policy practitioners from UNCTAD, UNECA, and GPRVC.[90] These interviews reveal an emerging expert consensus on the necessity of consultative governance and pragmatic market integration in resolving infrastructural and financial bottlenecks.

[88] Peter Evans, Embedded Autonomy: States and Industrial Transformation, 45.
[89] Ibid.
[90] See Introduction.

5.1 Expert Assessment of Industrial Policy

a. Value Addition and Export Strategies

One central debate in our interviews concerns where developing countries should position themselves within energy transition value chains. Experts broadly agree that gradualism – the adoption and implementation of policies through incremental and continuous steps – should be prioritised over leapfrogging, which seeks to bypass existing domestic infrastructure and productive capabilities to enter directly into advanced manufacturing sectors.[91] However, practitioners diverge on how gradualism should be sequenced in practice and on the most appropriate entry point for countries to pursue.

Freire Junior advocates a gradual, adjacency-based approach rooted in the economic complexity framework, whereby emerging economies should expand into products close to their existing productive capabilities.[92] Without the requisite skilled local labour and manufacturing capabilities in place, core technological knowledge and managerial assets across the value chain are likely to remain concentrated among foreign actors, subsequently constraining endogenous learning and limiting domestic capability accumulation.

A potential remedy is proposed by Oliver Braunschweig, through the adoption of strategic coupling,[93] which means a regulated collaborative arrangement between local entities and leading foreign companies.[94] Through regulating the integration of local labour and facilitating structured knowledge transfer, these partnerships ensure that manufacturing capabilities are built upon existing domestic operations rather than bypassing them.

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[91] Segun Michael Ojo and Edward Oladipo Ogunleye, "Technological Leapfrogging and Manufacturing Value-Added in Sub-Saharan Africa (1990–2018)," (2021), https://doi.org/10.48550/arXiv.2103.16049.
[92] Freire, interview.
[93] Braunschweig, interview.
[94] Jeffrey Neilson, Angga Dwiartama, Niels Fold, and Dikdik Permadi, "Resource-Based Industrial Policy in an Era of Global Production Networks: Strategic Coupling in the Indonesian Cocoa Sector," World Development 135, no. 11 (2020): 105045, https://doi.org/10.1016/j.worlddev.2020.105045.

Tom Moerenhout shares a distinctive, more pragmatic perspective that prioritises the immediate maximisation of existing export potential as a precondition for further infrastructural change. He stresses that competitiveness depends primarily on having a credible buyer. In other words, countries should first identify where their output can be sold, and at what cost, before scaling production. He suggests that developing economies should first generate revenue and employment stability to establish the economic foundation necessary for longer-term industrial upgrading. In particular, Moerenhout acknowledges the dominance of established competitors, such as China, which holds an absolute advantage in vertical integration across CETM value chains.[95] He suggests that emerging economies should secure pragmatic export arrangements with these competitors before attempting to occupy complex new production niches. For instance, a bundled export deal combining upstream minerals with selected minor midstream components could be negotiated with China to offer a more realistic entry point. Such an application prevents economies from overreaching into near-finished downstream goods where competitive positioning remains unrealistic in the near term.[96]

Taken together, these perspectives highlight a shared political economy realism, emphasising that industrial goals must remain compatible with the operational capacity of the state and the immediate demand of global offtake markets. At the same time, all four experts agree that policy design should be context-specific. Identical policy instruments may yield divergent outcomes across CETM and commodity structures. As a result, scenario planning is essential to address sudden volatility in value chain demand.

b. Institutional and Governance Realities

Local political conditions and governance capacity cannot be treated as background variables in policy design. The central challenge is to combine inclusive policy formulation with stable institutional mechanisms shielded from abrupt political interference.

Braunschweig argues that theoretically optimal policies might rest on idealised preconditions of market function and institutional capacity. In contexts such as Namibia, Zambia, and Madagascar,

[95] Moerenhout, interview.
[96] Ibid.

where states lack sufficient financial resources and regulatory capacity to enforce compliance, well-intentioned policies risk being captured by political interests or undermined by administrative or socio-political gaps, first-best instruments often introduce new frictions rather than resolving existing ones.[97] Defining a market failure, in his view, requires a combination of theoretical grounding and large doses of context-specific judgement, focused on identifying which mechanisms are genuinely not working in a given setting. When incoming administrations redirect inherited programmes to serve new political constituencies, it undermines the long-term institutional commitment that industrial capability-building requires.[98]

Maponga presents an “all of government” approach that necessitates the establishment of an inter-ministerial workforce to oversee the nation’s trade, education, and technological advancement; in coordinated efforts with community stakeholders and foreign business rather than viewing them as passive recipients of policy. Such a participatory model ensures local actors’ needs and benefits are well considered in the industrial process, thereby enhancing the clarity and legitimacy of policy making.[99] Echoing Freire, Maponga stresses that close coordination between education and industry ministries is essential to align the expansion of the domestic manufacturing base with the development of a skilled workforce, preventing the phenomenon of “brain drain” in which local human capital migrates towards advanced economies, given the unavailability of relevant industrial positions,[100] inadvertently subsidising the human capital of foreign markets rather than contributing to regional beneficiation. Maponga also highlights the strategic investment in infrastructure. Infrastructure serves as a fundamental public input that enhances export capabilities and national security. In the extractive sector, for example, Oliver Maponga highlights that specialised infrastructure, such as SEZs, provides the essential link between domestic production and international markets.[101]

[97] Ibid.; Braunschweig, interview.
[98] Braunschweig, interview.
[99] Maponga, interview.
[100] Catia Batista, Daniel Han, Johannes Haushofer, Gaurav Khanna, David McKenzie, Ahmed Mushfiq Mobarak, Caroline Theoharides, and Dean Yang, "Brain Drain or Brain Gain? Effects of High-Skilled International Emigration on Origin Countries," Science 388, no. 6749 (2025): eadr8861, https://doi.org/10.1126/science.adr8861.
[101] Oliver Maponga, interview by the authors, March 26, 2026.

These insights expose a critical tension at the heart of governance design. As policy formulation becomes more inclusive, insulating implementation from political interference grows more difficult. Navigating between deliberative legitimacy and operational continuity remains a defining challenge for the three economies under study.

c. Economies of Scale and Market Readiness

Effective industrial policy must reconcile two fiscal imperatives: attracting international capital while safeguarding domestic economic autonomy. Experts converge on the centrality of bankability, regional integration, to tackle small national domestic market scale and justify large-scale projects independently[102] – and infrastructure as the conditions under which scale becomes achievable.

Regional integration offers a more immediately accessible route to scale than global value chain entry. The collaboration between Zambia and Zimbabwe, exemplified by the establishment of the Zambia-Zimbabwe Common Agro-Industrial Park and the commitment to remove all barriers that affect trade,[103] illustrates how cross-border cooperation can generate the economies of scale that individual countries cannot feasibly achieve alone. Maponga further notes that in economies like Zambia, where over 85 per cent of local businesses are SMEs, foreign investment should explicitly incorporate domestic business participation and employment needs to sustain the public consensus necessary for long-term infrastructural development.[104] When sectors are dominated by SMEs that form the backbone of local employment, financial support should go beyond efficiency-based criteria, considering socio-political challenges to secure investments.

Moerenhout argues that policy design should secure guaranteed offtake agreements before pursuing concessional finance, building on his earlier proposals regarding collaborating with established global players like China. By establishing quantifiable demand through guaranteed

[102] Moerenhout, interview
[103] COMESA Secretariat Corporate Communications Unit, "eCOMESA Issue #766," newsletter (November 7, 2025), https://www.comesa.int/wp-content/uploads/2025/11/e-comesa-766.pdf; Government of Zimbabwe and Government of Zambia, "Joint Communiqué Issued at the Conclusion of the Working Visit by the President of the Republic of Zambia, Mr. Hakainde Hichilema and the Inaugural Bi-National Commission Between the Republic of Zimbabwe and the Republic of Zambia," government statement (November 14, 2025), 3, https://www.mofaic.gov.zm/wp-content/uploads/2025/11/14-NOVEMBER-JOINT-COMMUNIQUÉ-FOR-THE-ZIM-ZAM-BNC.pdf.
[104] Maponga, interview.

off-take agreements, policymakers signal commercial credibility to international investors, thereby reducing perceived risk and unlocking foreign capital for industrial scaling.[105] He further observes that direct technical support from investors typically delivers more value than minor tax incentives, which in low-income settings tend to start from a low base. Bankability also depends on credible domestic conditions: for instance, fixing the regulatory environment in the energy sector – reducing both technical losses (grid transmission) and non-technical losses (such as theft and non-payment) – would allow independent power producers to participate. Without these foundations, even well-conceived projects struggle to attract financing at viable interest rates.

Beyond scale, inadequate energy infrastructure remains a binding constraint on market readiness. Given that electricity access across all three studied countries falls below 60 per cent,[106] foundational conditions for energy-intensive manufacturing are fragile. Moerenhout proposes grid diversification – including solar-plus-battery solutions because most new hydropower projects are simply economically unviable – as a twofold solution that improves supply reliability while reducing the corruption risks that tend to accumulate around centralised energy monopolies.[107] In addition, experts recommended the creation of SEZs as an effective mechanism for clustering the foundational infrastructure (power, water, transport), achieving economies of scale within a stable business environment that capital-intensive projects demand.[108] Moerenhout further emphasises the centrality of food security to this agenda: drawing on Malaysia's experience, he notes that a stable and adequately fed population is a precondition for the social cohesion on which long-term industrial strategies depend.

d. Socio-Environmental Intersections

Beyond financial and geopolitical viability, social and environmental advancement is also fundamental for effective industrial policy.[109] Freire challenges the common framing of environmental

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[105] Moerenhout, interview.
[106] World Bank, "Access to Electricity."
[107] Moerenhout, interview; Godinho, Catrina, and Samuel Mwita Wangwe. "Power Sector Reform and Regulation." Chapter. In *State and Business in Tanzania's Development: The Institutional Diagnostic Project*, edited by François Bourguignon, 262–99. Cambridge: Cambridge University Press, 2023. https://doi.org/10.1017/9781009285803.016
[108] Susanne A. Frick and Andrés Rodríguez-Pose, "What Draws Investment to Special Economic Zones? Lessons from Developing Countries," Regional Studies 57, no. 11 (2023): 2136–47, https://doi.org/10.1080/00343404.2023.2185218.
[109] Clement Sefa-Nyarko, "Beyond Geopolitics: Social License and Supply Chain Risks of Critical Minerals," *Energy Research & Social Science* 131 (2026): 104490, https://doi.org/10.1016/j.erss.2025.104490.

standards as a barrier to industrialisation. He explains that the pursuit of responsible mining and manufacturing should be driven by competitive self-interest rather than external pressure, thereby incentivising the advancement of domestic processing capacity that meets international market requirements. In his experience, governments in the countries studied have responded positively to this reframing, viewing standards as an avenue for market positioning rather than a constraint. This alignment strengthens export potential by ensuring compliance with climate-related trade regulations of international buyers. Hence, Freire suggests that sustainability considerations should be systematically embedded in policy decision processes from the outset.[110]

Another issue emphasised by Maponga[111] is that governance conditions must ensure these infrastructures and local development programs are inclusive. This includes community development agreements between the private sector and local communities to ensure that mining is done with consensus, and that the infrastructure and skills remain transferable and beneficial for socioeconomic transformation when mining activities end. At the regional level, Maponga points to instruments, like the African Mining Vision and the African Green Minerals Strategy, as offering clear guidance for member states to align national minerals policies with sustainability commitments.[112]

In addition, Braunschweig offers a pragmatic reframing of environmental oversight for contexts of limited regulatory capacity. Rather than attempting comprehensive environmental governance from the outset, policymakers should first focus on tractable issues with direct welfare implications, such as health and education. For instance, strategically sequencing the management of adverse mining impacts, using public health outcomes as a primary metric, might help boost public trust and political legitimacy. Over time, this could support more comprehensive environmental governance that addresses both ecological integrity and social well-being.[113]

[110] Freire, interview.
[111] Maponga, interview.
[112] African Union, *Africa Mining Vision* (African Union, 2009), 39-42, https://au.int/sites/default/files/documents/30995-doc-africa_mining_vision_english_1.pdf; African Union, *Africa's Green Minerals Strategy* (African Union, 2024), 78, https://au.int/sites/default/files/documents/44539-doc-AGMS_Final_doc.pdf.
[113] Braunschweig, interview.

5.2 Synthesis of Findings and New Conclusions

The previous analyses in Sections 2–4 converge on a fundamental insight for CETM-driven economic development: successful value addition in solar and wind supply chains demands context-specific institutions that ensure investor security and productive stability. The economist Dani Rodrik[114] argues that prosperity in rich nations stems from institutional arrangements in which investors feel protected by effective rules, while poor countries lack such arrangements, regardless of formal legislation. Rodrik's framework, applied here to Southern Africa's CETM context, underscores that Zambia, Namibia, and Madagascar cannot replicate Western judicial independence overnight. They can, however, foster hybrid mechanisms tailored to local realities, such as SEZs that combine public oversight with private incentives, off-take agreements that signal demand to international investors, and inter-ministerial coordination bodies that insulate implementation from short-term political cycles. This section synthesises these findings to draw new conclusions for developing countries pursuing energy transition industrialisation.

Building on the principles set out in Section 5.1, this synthesis rejects one-size-fits-all prescriptions and advocates instead for diagnostic, sequenced strategies that leverage each country's product-level potential – as identified through the HS code analysis – while addressing the specific institutional gaps mapped in Section 2.1. The following analysis applies this framework to derive tailored conclusions for Namibia, Zambia, and Madagascar. The findings of this report point to a broader and more general conclusion about industrialisation in resource-rich developing countries: the central challenge is not simply how to design good industrial policies, but how to make them credible, socially grounded, and workable in specific political and institutional settings. In other words, one should consider policy space as multidimensional.[115] The syntheses below translate this overarching framework into tailored conclusions for the three countries.

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[114] Dani Rodrik, "Institutions and Economic Performance: Getting Institutions Right," CESifo DICE Report 2, no. 2 (2004): 10–15; Rodrik, Dani, Arvind Subramanian, and Francesco Trebbi. 'Institutions Rule: The Primacy of Institutions Over Geography and Integration in Economic Development'. *Journal of Economic Growth* 9, no. 2 (2004): 131–65. https://doi.org/10.1023/B:JOEG.0000031425.72248.85.

[115] Boys, Julian, and Antonio Andreoni. 'Does Regionalism Increase Industrial Policy Space? An Analytical Framework Applied to the East African Textiles and Apparel Sector'. *Third World Quarterly* 44, no. 8 (2023): 1680–98. https://doi.org/10.1080/01436597.2023.2211009.

a. Namibia: From Primary Exports to Value-Added Manufacturing

Following UNCTAD's assessment,[116] Namibia's structural economic transition necessitates moving away from the exportation of primary raw minerals toward the development of viable value-added products. Within CETM value chains – and based on export potential linked with local capabilities – priorities should be focused on the manufacturing of copper-based electrical components (wiring, conductors, switchgear), iron and steel products, and industrial machinery. Beyond the extractive sector, advanced food processing – and fisheries for example, where political economy considerations linked to the sector's close relationship with the Namibian government[117] support faster policy uptake – and the chemicals sector, accounting for roughly 17 per cent of all shortlisted opportunities by UNCTAD, primarily driven by inorganic chemicals such as copper and titanium oxides, but also, beyond CETMs, organic and mixed chemicals to broaden the opportunity further.[118]

The institutional framework supporting this transition is codified in the Sixth National Development Plan,[119] reinforced by the 2023 legislative ban on exportation of unprocessed lithium and analogous critical minerals.[120] Operationalisation depends on sustained political coordination between the Namibia Investment Promotion and Development Board and the Ministry of Industrialisation and Trade, with SEZs serving as the principal vehicle for combining regulatory reforms with targeted investment incentives.[121]

Namibia's role as a logistical hub for the Southern African region is central to this strategy. The modernisation of the Port of Walvis Bay facilitates global maritime trade and serves regional markets – including Angola, Zambia, Botswana, and the DRC – in alignment with the African Continental

[116] UNCTAD. *Rapid Assessment of Value Addition and Diversification within and beyond the Critical Energy Transition Minerals Value Chain: Namibia*. 2026.
[117] Corruption Watch. 'Still No Justice for Workers Impoverished by Fishrot Corruption Scandal'. *Corruption Watch*, 28 November 2024. https://www.corruptionwatch.org.za/still-no-justice-for-workers-affected-in-fishrot-corruption-scandal/.
[118] UNCTAD. *Rapid Assessment of Value Addition and Diversification: Namibia*. 2026
[119] National Planning Commission. Namibia's Sixth National Development Plan (NDP6): Fostering Economic Growth, Inclusiveness and Resilience for Sustainable Development 2025/26 to 2029/30. Windhoek: National Planning Commission, 2025. https://www.npc.gov.na/wp-content/uploads/2025/07/NDP6-Policy-Document_compressed.pdf
[120] IEA. 'Export Ban on Raw Materials – Policies'. 2025. https://www.iea.org/policies/28970-export-ban-on-raw-materials.
[121] Zeng, Douglas Z. 'The Past, Present, and Future of Special Economic Zones and Their Impact'. *Journal of International Economic Law* 24, no. 2 (2021): 259–75. https://doi.org/10.1093/jiel/jgab014.

Free Trade Area (AfCFTA) and the Southern African Development Community (SADC) frameworks. Realising these ambitions, however, hinges on resolving two binding constraints. First, it requires investment in domestic renewable energy generation to tackle systemic energy deficit (relying disproportionately on energy imports, 58-67 per cent of annual demand, from the Southern African Power Pool).[122] Second, given that water is integral to both food security and advanced manufacturing,[123] investment in desalination infrastructure is required to ensure that expanded manufacturing does not precipitate social and ecological degradation.

b. Zambia: From Copper Dependence to Diversified Industrial Base

UNCTAD's assessment on Zambia[124] identifies an aggregate export potential of US$1.4 billion for Zambia, encompassing more than 400 viable value-added products distributed across 25 distinct industrial sectors. While 73 of these commodities are intrinsically linked to the CETM value chain – most notably copper cabling and cobalt refining – the national strategy emphasises downstream diversification, entailing scaled domestic production of industrial chemicals (including fertilisers, copper sulphates, and carbonates), steel, plastics, electrical and mechanical machineries, and food processing.[125]

Institutionally, the Eighth National Development Plan,[126] and the Critical Minerals Strategy,[127] together provide the legal and strategic foundation for industrial upgrading, with SEZs serving as the principal instrument for mitigating localised infrastructure and regulatory constraints.[128]

Yet, as interviews we conducted emphasised, the credibility of these frameworks ultimately depends on insulating implementing agencies from short-term political pressures while preserving

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122 Government of the Republic of Namibia. *National Energy Compact for Namibia*. 2024, 21.
123 UNCTAD, *Rapid Assessment of Value Addition and Diversification: Namibia,* 2026.
124 UNCTAD. *Rapid Assessment of Value Addition and Diversification within and beyond the Critical Energy Transition Minerals Value Chain: Zambia*. 2026.
125 UNCTAD, *Rapid Assessment of Value Addition and Diversification: Zambia,* 2026.
126 Ministry of Finance and National Planning. 'Zambia Eighth National Development Plan 2022-2026, (2022).
127 Ministry of Mines and Minerals Development. *National Critical Minerals Strategy 2024 - 2028*. Lusaka: Ministry of Mines and Minerals Development, 2024.
128 Fessehaie, Judith, and Zavareh Rustomjee. "Resource-based industrialisation in Southern Africa: Domestic policies, corporate strategies and regional dynamics." *Development Southern Africa*35 (2018): 404-18. https://doi.org/10.1080/0376835x.2018.1464901.

structured channels for private sector and civil society feedback. This balance that remains one of Zambia's principal governance challenges, given a CPI score of 37/100.[129]

As a landlocked nation, Zambia's export capacity depends on strategic transport infrastructure investments, including the Lobito Corridor for rail connectivity with Angola and the DRC.[130] Without these corridors, manufacturing capabilities cannot translate into sustained export performance. Energy grid stabilisation is equally critical, given the country's reliance on hydropower (predominantly via the Kariba Dam) and vulnerability to prolonged droughts.[131] Diversifying the energy mix through expanded solar and wind generation is therefore a matter of supply security and a precondition for sustaining the energy-intensive processing activities that define the country's value addition strategy. Regional integration, particularly cross-border initiatives such as the Zambia–Zimbabwe Common Agro-Industrial Park, further offers a pragmatic pathway to achieving the economies of scale that the domestic market alone cannot deliver.

c. Madagascar: Critical Metals and Green Industrial Development

Madagascar's industrial trajectory is anchored in the extraction and beneficiation of critical metals, with emphasis on graphite processing, nickel, and cobalt,[132] used for instance in batteries. These endowments translate into concrete export opportunities, most notably in parts of electric accumulators and metal permanent magnets, where the weighted global opportunity could lift these products from a near-zero base to a meaningful share of total exports. Realising this potential requires a dual policy track: at the central level, regulatory streamlining to attract FDI for high-demand battery metal beneficiation; at the local level, structured support to formalise the largely unorganised landscape of small-scale informal mining, particularly in gold.[133]

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[129] Transparency International, "Corruption Perceptions Index 2025: Zambia — Score and Rank."
[130] OECD. *Panel 2 OECD EMF Background Note - The Lobito Corridor*. Paris: OECD, 2025.
[131] Nyoni, Kumbuso Joshua, Anesu Maronga, P. Tuohy, and Agabu Shane. "Hydro–Connected Floating PV Renewable Energy System and Onshore Wind Potential in Zambia." *Energies* (2021). https://doi.org/10.3390/en14175330.
[132] Fabien, Randrianasolo, Andriamiadanomenjanahary Camille, Rakotoarisoa Eliane, and Rafamantanantsoa Hasina. "Mining in Madagascar: Optimizing the Added Value with Gold Sector." *International Journal of Economics, Finance and Management Sciences* (2025). https://doi.org/10.11648/j.ijefm.20251303.14.
[133] Ibid.

With a coastline of more than 4,800 kilometres and a strategic position on major trade routes between Asia and Southern Africa, Madagascar holds significant potential as both a regional logistics hub and a node within global battery value chains. Global trade integration, however, requires comprehensive modernisation of deep-water port infrastructure,[134] and a parallel expansion of energy-intensive processing capacity. Given the country's critically low grid integration, this transition cannot rely on centralised power alone; it must combine localised off-grid renewables for community and small-industry use with industrial-scale generation for mineral processing.

Lastly, the main issue remains Madagascar's multi-dimensional poverty and food insecurity;[135] national industrialisation cannot be conceptualised independently of these existential socio-economic realities. Economic policy would, therefore, have to be integrated with robust climate resilience and food security initiatives, enhancing local trust and institutional development to foster the essential first step toward long-term, sustainable economic growth. Moreover, this framework should mitigate tensions between extractive industry expansion and the preservation of Madagascar's globally distinct biodiversity. This calls for rigorous environmental impact assessments, the institutionalisation of free, prior and informed consent (FPIC) mechanisms, and structured community participation. These measures, indeed, would safeguard rural and Indigenous populations, while securing the social licence on which long-term industrial credibility ultimately depends.

6. Conclusion

The global energy transition is reshaping international trade and creating a strategic opening for resource-rich developing countries to participate in higher-value manufacturing. Namibia, Zambia, and Madagascar each possess the mineral endowments, the renewable resource base, and – to varying degrees – the institutional foundations needed to participate meaningfully in solar PV and wind value chains. Yet, endowments alone explain little: what matters is whether countries can translate those

[134] Munim, Z. H., and H. Schramm. "The impacts of port infrastructure and logistics performance on economic growth: the mediating role of seaborne trade." *Journal of Shipping and Trade* 3 (2018). https://doi.org/10.1186/s41072-018-0027-0.
[135] Fayad, Dominique. "Food Insecurity and Climate Shocks in Madagascar." *Selected Issues Papers* (2023). https://doi.org/10.5089/9798400242601.018.

endowments into productive capabilities through context-specific institutional arrangements, realistic industrial ambitions, and the integration of economic policy with broader development imperatives.

This report has approached this question in three steps. First, the HS code analysis (Appendix B) identified practical entry points for value addition in each country. Second, the conceptual framework (Section 4) and related case studies (Appendix C) situated these opportunities within empirical evidence on what makes industrial policy successful, or not. Third, expert interviews (Section 5) tested these findings against the practical realities facing policymakers in Southern Africa today. The convergence across these three layers of evidence is striking: the most promising opportunities for Namibia, Zambia, and Madagascar lie in capability-proximate products where the gap between current exports and the weighted world opportunity is large enough to be meaningful, and institutional and infrastructural barriers, while real, are manageable.

The empirical record from Indonesia's nickel downstreaming,[136] Chile's lithium hydroxide failures,[137] and the broader literature on resource-based industrialisation show that policies which look identical on paper can yield radically different outcomes depending on local institutional context, sector-specific frictions, and political economy. Indonesia's export ban succeeded for nickel because it coincided with massive Chinese capital seeking proximity to EV battery markets, but the same logic damaged the bauxite industry, where global demand and capital availability were absent. Chile's two consecutive failures (2018 and 2025) to develop lithium hydroxide production despite generous concessional pricing illustrate that subsidies alone cannot offset contractual ambiguity, water scarcity, and weak coordination across ministries. Building with the product-level analysis (Appendix B), carrying direct implications for industrial policy design, the Namibian, Zambian, and Madagascan cases sit somewhere between these poles, and the policy conclusions below are calibrated accordingly.

Drawing from the conceptual framework (Section 4, recommendations IV to VI), Oliver Braunschweig's Industrial Policy Framework produced for GPRVC (recommendation II), and experts interviews (Section 5, recommendations I and III), six general strategic recommendations emerge:

[136] See Appendix C
[137] Ibid.

I. Adopt gradualist, adjacency-based industrial strategies. Countries should expand into products that are proximate to their existing productive capabilities, resisting the temptation to leap directly into the most advanced segments of the value chain. The HS code findings illustrate why this matters in practice. Strategic coupling with global lead firms – regulated partnerships with mandated local content and structured knowledge transfer provisions – offers a viable mechanism for capability accumulation, provided the local political economic context is properly understood.

II. Give implementation, monitoring, and adaptive revision at least as much weight as initial policy design. Industrial policy debates in developing countries often concentrate on the design phase, including which subsidies to offer, which sectors to prioritise, and which export bans to impose. Braunschweig's framework addresses this imbalance directly. Policies should be reviewed at regular intervals and adapted based on transparent, structured evaluation. Hence, industrial policies should be seen as living instruments, supported by independent monitoring bodies with the technical capacity to track product-level export performance against the targets identified through tools such as UNCTAD's.

III. Integrate industrial policy with broader development goals; do not pursue industrialisation in a vacuum. Industrial diversification cannot succeed where its preconditions, namely food security, energy access, human capital formation, and environmental sustainability, remain unmet. Countries facing acute food insecurity or severe energy deficits should sequence industrial upgrading alongside, not in isolation from, these foundational investments – and international finance frameworks should be structured to support that sequencing rather than penalise it.

IV. Strengthen regional cooperation and market integration to overcome the limits of small domestic markets. Each of the three countries has a domestic market too small to sustain, on its own, the economies of scale that capital-intensive processing requires. SADC, COMESA, and AfCFTA frameworks offer institutional pathways for shared refining hubs, regional power pools, and coordinated transport infrastructure development. Strategic logistics investments – e.g., the modernisation of the Port of Walvis Bay, the development of the Lobito Corridor, the rehabilitation of the TAZARA railway, and the investments in deep-water ports – are preconditions for manufacturing capabilities to translate into export performance.

V. Ensure institutional credibility and embedded autonomy. Industrial policy implementation requires agencies that are insulated from short-term political pressures while remaining structurally embedded in the private sector, civil society, and academic networks that supply the information needed to adjust policy in real time. For countries where comprehensive governance reform is not feasible in the short term, SEZs can serve as practical testing grounds for institutional innovation, blending public oversight with private incentives within a delimited geographic and regulatory perimeter. Investor security requires consistency, predictability, and credible commitment within whatever institutional architecture exists.

VI. Safeguard environmental and social sustainability as a strategic asset, not a regulatory burden. CETM-related industrial development must incorporate rigorous environmental impact assessments, structured community consultation, and Free, Prior, and Informed Consent mechanisms as core governance requirements. Compliance with climate-related trade regulations – including the EU's Carbon Border Adjustment Mechanism, the Critical Raw Materials Act, and the increasingly stringent ESG requirements imposed by lithium and battery off-takers – is rapidly becoming a precondition for accessing high-value export markets. Indeed, projects that ignore ecological limits and community interests face higher resistance and lower returns. Institutionalising sustainability early should therefore translate into a competitive advantage.

Taken together, these six recommendations chart a sequenced path. They begin from each country's existing productive structure, reinforce that structure with institutional credibility and adaptive governance, embed industrial policy within broader development goals, and extend its reach through regional cooperation and credible sustainability commitments. Ultimately, the success of

CETM-based industrialisation in Southern Africa will be determined not by the ambition of policy documents but by the quality of institutions that translate policy into practice.

The energy transition can catalyze long-term domestic prosperity, but only if it is pursued through realistic, sequenced strategies embedded in each country's social, political, and economic context. By integrating product-level evidence from UNCTAD's tool, lessons from comparable case studies, and the practical insights of policy practitioners working in the region, this report offers UNCTAD and GPRVC an actionable framework for advancing that objective and supporting Namibia, Zambia, and Madagascar in capturing a fairer share of the value generated by the global energy transition.

In conclusion, the six recommendations outlined above, together with the country-specific analyses that precede them, are not intended as a general policy blueprint, nor as a checklist to be applied uniformly across Namibia, Zambia, and Madagascar. We propose them as a systemic vision: an attempt to articulate the structural logic that, according to us, should inform industrial policy design for value addition in CETM-related value chains, while leaving the substance of each instrument to be negotiated, sequenced, and recalibrated within the specific institutional, political, and ecological context of each country.

We want to underscore that the analytical contribution of this report acquires meaning only when it becomes the starting point of a broader conversation, one that brings together not only governments, international organisations, and investors, but also the actors whose voices are too often absent from industrial policy debates: small-scale and informal miners, women in extractive value chains, and, in particular, Indigenous and local rural communities whose territories, livelihoods, and knowledge are directly implicated in any decision to expand mineral extraction or downstream processing. The energy transition will not be just if it reproduces the extractive asymmetries of previous industrial cycles, and it will not be durable if the populations exposed to its environmental and social externalities are excluded from shaping its terms. We therefore offer this report not as a set of definitive answers, but as an invitation to thoughtful deliberation, and we hope it will be read and used in that spirit.

Acknowledgement of the Use of Artificial Intelligence

In accordance with the IHEID's *Rules and Good Practices for Ethical Use of Artificial Intelligence in Academic Work*, the authors hereby disclose the use of generative AI tools in the preparation of this report.

Generative AI was used in a limited and strictly supportive capacity for the following purposes:

- Language assistance, specifically to check grammar and spelling across the manuscript;
- Bibliography and citation management, complemented with Zotero, to verify reference formatting and ensure consistency;
- Construction of some tables, used to organise information in a clear and structured format.

The authors confirm that AI tools were used to support and enhance their work, not to substitute for it.

APPENDIX A: In-Depth Analysis of the Three Countries

a. Namibia's Overview

Namibia, situated on the southwest coast of Africa, is characterised by vast semi-desert landscapes across 825,000 km². It is the Sub-Saharan Africa's driest country and one of its least densely populated, with just over 3.1 million people (53.7 per cent urban). Namibia is a diverse, multi-ethnic society with at least eleven distinct ethnic groups. Since its independence in 1990, the country has established democratic institutions and achieved development advances in infrastructure, education, and health access. These gains supported Namibia's transition to upper-middle-income status in the late 2000s, although the country was reclassified as a lower-middle-income economy in 2025 following a drop in gross national income (GNI) per capita.[138]

In 2024, Namibia ranked 144th globally in gross domestic product (GDP) of US$13.4 billion,[139] and 89th on the ECI. It remains heavily dependent on mining, which dominates over 50 per cent of exports, that are led by diamonds (US$1.17 billion), uranium/thorium ore (US$1.08 billion), radioactive chemicals (US$847 million), and gold (US$821 million) to key destinations including China (US$1.83 billion), South Africa (US$1.25 billion), Botswana (US$973 million), Belgium (US$705 million), and Zambia (US$508 million).[140]

Namibia's vast renewable energy potential, with solar irradiation of 2,700 kWh/m²/year and average wind speeds exceeding 7 m/s along 1,700 km of southern/coastal regions, holds considerable opportunities for socio-economic development and industrialisation.[141] This is exemplified by clean energy projects like the green hydrogen Hyphen initiative, which aims to use renewable power for large-scale hydrogen production.[142] Namibia holds significant potential to diversify its economy by

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[138]World Bank, "Namibia: Overview," last modified September 30, 2025, https://www.worldbank.org/ext/en/country/namibia.

[139] International Monetary Fund (IMF), "Gross Domestic Product, Current Prices (NGDPD) – Namibia," *World Economic Outlook Database*, accessed March 30, 2026, https://www.imf.org/external/datamapper/NGDPD@WEO/NAM.

[140]Observatory of Economic Complexity (OEC), "Namibia," accessed March 30, 2026, https://oec.world/en/profile/country/nam.

[141]International Energy Agency, *Renewable Energy Opportunities for Namibia* (IEA, 2024), https://iea.blob.core.windows.net/assets/4752b1af-c40c-4667-827e-7f57b6fee3f2/RenewableEnergyOpportunitiesforNamibia.pdf.

[142]Hyphen Hydrogen Energy is developing a green hydrogen project in Namibia of over US $10 billion, targeting the production of 3 million tonnes per annum (MPTA) of green hydrogen. Located in the Tsau ||Khaeb National Park, and in and around the local towns of Lüderitz and Aus, the project is a cornerstone of Namibia's Southern Corridor Development

building on both its existing exports and emerging capabilities. Preliminary UNCTAD results identify organic chemicals, iron/steel, and machinery as strong opportunities within and beyond CETM value chains. Regional and global demand align with these strengths, offering pathways to industrial growth and economic complexity.[143]

Yet structural constraints persist. Energy access reaches only 56.7 per cent (2023), with domestic generation covering less than half of needs.[144] The number of people facing food insecurity fell to its lowest level in mid-2025 at 456,000 people (15 per cent) due to good rains. However, is projected to rise to 612,000 (20 per cent) in the 2025/26 lean season amid ending drought relief, 36.9 per cent unemployment, and livestock losses.[145] Moderate corruption, with 46 points out of 100 according the 2025 Corruption Perceptions Index (CPI), signals governance risks.[146] Infrastructure strengths include Walvis Bay's deep-water port and planned rail/road corridors linking to SADC markets, but manufacturing remains nascent.

b. Zambia's Overview

Zambia is a landlocked, resource-rich country situated in the centre of Southern Africa. It shares borders with eight neighbours (Angola, Botswana, Democratic Republic of Congo, Malawi, Mozambique, Namibia, Tanzania, Zimbabwe) that expand its regional market potential for goods and services. Zambia is experiencing a large demographic shift and is one of the world's youngest countries by median age. Its population is estimated at 22.5 million (47.4 per cent urban) with a growth rate of 2.77 per cent per year. As the large youth population attains reproductive age, the population is anticipated to double in the next 25 years, resulting in additional pressure on jobs, health care, education and other social services.[147]

Initiative (SCDI), with construction phases starting in 2026 to create thousands of jobs. https://hyphenafrica.com/the-hyphen-project/#:~:text=Southern%20Corridor%20Development%20Initiative,strategy%20to%20minimise%20environmental%20impacts.

[143] UNCTAD, "Critical Energy Transition Minerals in Southern Africa."

[144] World Bank, "Access to Electricity – Namibia, Madagascar, Zambia;" International Energy Agency, *Renewable Energy Opportunities for Namibia*.

[145] Integrated Food Security Phase Classification (IPC), "Country Analysis Details Map," accessed March 30, 2026, https://www.ipcinfo.org/ipc-country-analysis/details-map/en/c/1159738/.

[146] Transparency International, "Corruption Perceptions Index 2025," February 10, 2026, https://www.transparency.org/en/cpi/2025.

[147] World Bank, "Zambia: Overview," last modified October 2025, https://www.worldbank.org/ext/en/country/zambia.

In 2024, Zambia ranked 117th globally in GDP (US$25.3 billion) and 95th on the ECI out of 130 economies. Copper dominates exports (more than 50 per cent share), with raw copper (US$7.44 billion, world's largest exporter), refined copper (US$2.52 billion), nickel ore (US$624 million), precious stones (US$446 million), and raw tobacco (US$341 million) flowing primarily to Switzerland (US$4.8 billion), China (US$2.96 billion), India (US$1.96 billion), Democratic Republic of Congo (DRC) (US$1.2 billion), and South Africa (US$532 million).[148]

As a major copper producer, Zambia holds CETM value addition potential, complemented by solar irradiation (between 1,900-2,100 kWh/m²/year) and wind resources (5.6-6.4 m/s),[149] though hydropower highly dominates with around 88 per cent of total electricity generation.[150] Preliminary analysis by UNCTAD highlights that Zambia can strengthen its position in both CETM-related and adjacent sectors by promoting diversification into chemicals, machinery, and mechanical appliances, and food processing. Import substitution and regional trade integration offer practical entry points to build backward linkages and broaden the industrial base.[151]

Zambia is also marked by profound structural challenges. Electricity access reaches only 51.1 per cent of the population (2023),[152] acute food insecurity improved dramatically to 1.2 million people during May-September 2025 (down from 4.9 million in the 2024 drought crisis), but rose again to 1.7 million from October 2025 to March 2026.[153] A corruption score of 37/100 on the CPI signals serious governance risks for investment and industrial upgrading.[154] Manufacturing capacity remains limited to basic processing concentrated in the Copperbelt region, with heavy reliance on imported intermediates and machinery. Infrastructure challenges include landlocked status requiring transit

[148] Observatory of Economic Complexity (OEC), "Zambia," accessed March 30, 2026, https://oec.world/en/profile/country/zmb.
[149] Government of the Republic of Zambia (GRZ), *Renewable Energy Strategy and Action Plan* (RESAP), (GRZ, 2022).
[150] International Energy Agency, "Energy Mix – Zambia," accessed March 30, 2026, https://www.iea.org/countries/zambia/energy-mix.
[151] UNCTAD, "Critical Energy Transition Minerals in Southern Africa."
[152] World Bank, "Access to Electricity – Namibia, Madagascar, Zambia."
[153] Integrated Food Security Phase Classification (IPC), "Country Analysis Details Map: Zambia," accessed March 30, 2026, https://www.ipcinfo.org/ipc-country-analysis/details-map/en/c/1159771/?iso3=ZMB.
[154] Transparency International, "Corruption Perceptions Index 2025: Zambia — Score and Rank," February 10, 2026, https://www.transparency.org/en/cpi/2025/index/zmb.

through neighbouring ports/rail (Durban, Dar es Salaam, Lobito), chronic transmission losses, and skills shortages.[155]

c. Madagascar's Overview

Madagascar is the world's fifth-largest island, situated in the Indian Ocean off southern Africa, with a population of around 32.7 million in 2025. The country faces widespread poverty, weak job creation, and significant exposure to climate and economic shocks.[156] In 2024, it ranked 134th globally in GDP ($17.4 billion), and 190th in GDP per capita, while also placing 120th out of 130 economies on the ECI.[157] Its economy remains heavily dependent on low-productivity activities, especially small-scale subsistence agriculture. Since the 2010s, economic growth has averaged only about 3 per cent annually, which has been insufficient to keep pace with population growth of roughly 2.4 per cent per year, to generate jobs or reduce poverty.[158]

Despite some macroeconomic stability, structural constraints remain severe: infrastructure is weak, access to basic services is limited, natural disasters are frequent, and climate vulnerability is rising. Human capital is also very low, with a Human Capital Index of 0.39, among the weakest worldwide, while rural poverty remains deep and urban living standards have deteriorated over the past decade.[159] Food insecurity is another major concern, especially in the south and east of the country, where acute shortages persist due to climate shocks, the effects of political crisis, and reduced humanitarian support. In the current period, more than 1.57 million people are estimated to be facing acute food insecurity, including about 84,000 in Emergency conditions and 1.49 million in Crisis.[160]

At the same time, Madagascar has meaningful renewable energy and green industrial potential. Its coastal areas have wind speeds above 7 m/s and solar irradiation above 2,000 kWh/m²/year, while its

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155 World Bank, "Zambia's Copper Opportunity: Can the Workforce Keep Up?" *World Bank Feature Story*, September 10, 2025, https://www.worldbank.org/en/news/feature/2025/09/10/zambia-s-copper-opportunity-can-the-workforce-keep-up; Allegra Saggese, Benjamin Shawa, and Shahrukh Wani, *Positioning Zambia for a Copper-Plus Future: Policy Framing Paper*, IGC Policy Paper 23125 (International Growth Centre, February 2024), https://www.theigc.org/sites/default/files/2024-02/23125%20Copper-Plus%20Future_v5-WEB.pdf.

156 World Bank, "Madagascar: Overview," last modified 2025, https://www.worldbank.org/ext/en/country/madagascar.

157 Observatory of Economic Complexity (OEC), "Madagascar," accessed March 30, 2026, https://oec.world/en/profile/country/mdg.

158 World Bank, "Madagascar: Overview."

159 Ibid.

160 Integrated Food Security Phase Classification (IPC), ""Country Analysis Details Map: Madagascar," accessed March 30, 2026, https://www.ipcinfo.org/ipc-country-analysis/details-map/en/c/1161004/?iso3=MDG.

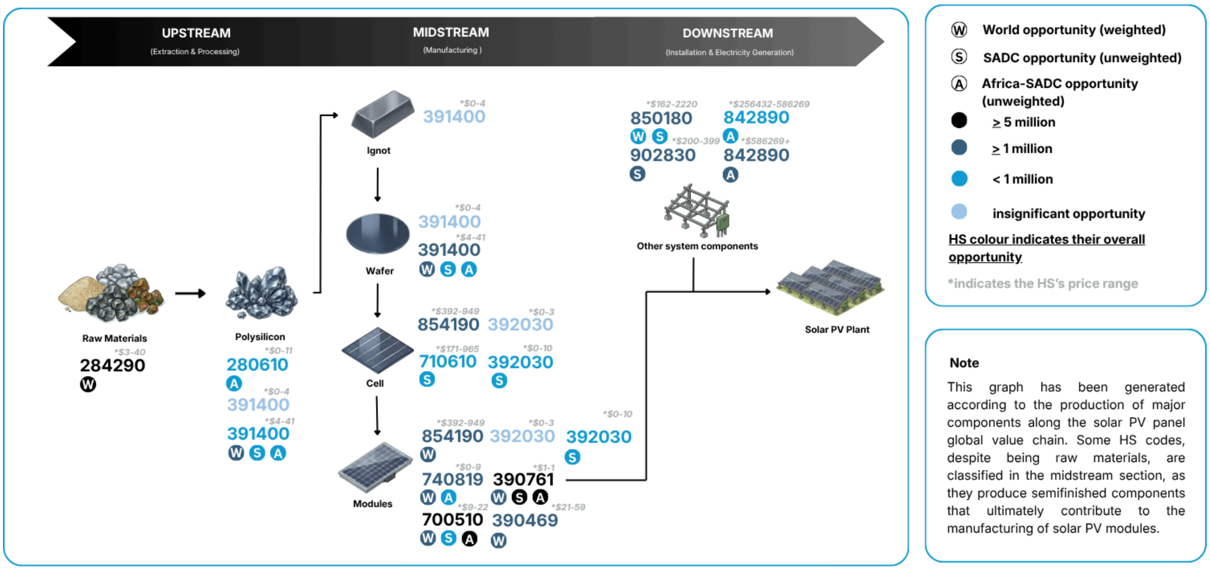
deposits of nickel, graphite, and cobalt offer strategic inputs for batteries, electrodes, and other clean energy technologies. These resources, especially high-quality graphite, could support Madagascar's entry into energy storage and broader green technology value chains.[161]

[161] Madagascar, Ministère de l'Énergie, *Expression of Interest to Participate in the Scaling Up Renewable Energy in Low-Income Countries Program (SREP)* (Ministère de l'Énergie, 2013), 4.

APPENDIX B: Detailed Harmonised System Codes Analysis

a. Namibia’s Opportunities Along the Value Chains of Solar and Wind

Fig. 1 : Illustrative Overview on Solar (PV) Energy GVC Segments for Namibia



Namibia's solar value-chain analysis identifies several HS codes with strong links to clean energy transition minerals (CETMs), particularly across chemicals, iron and steel, electrical machinery and plastics. Figure 1 maps the essential components and HS codes that define the solar energy supply chain. Within the set of identified opportunities, HS 284290 stands out on quantitative grounds. Table 1 below summarises the key figures for the main solar opportunity code.

Table 1. Namibia – Key solar and wind value-chain opportunity: HS 284290

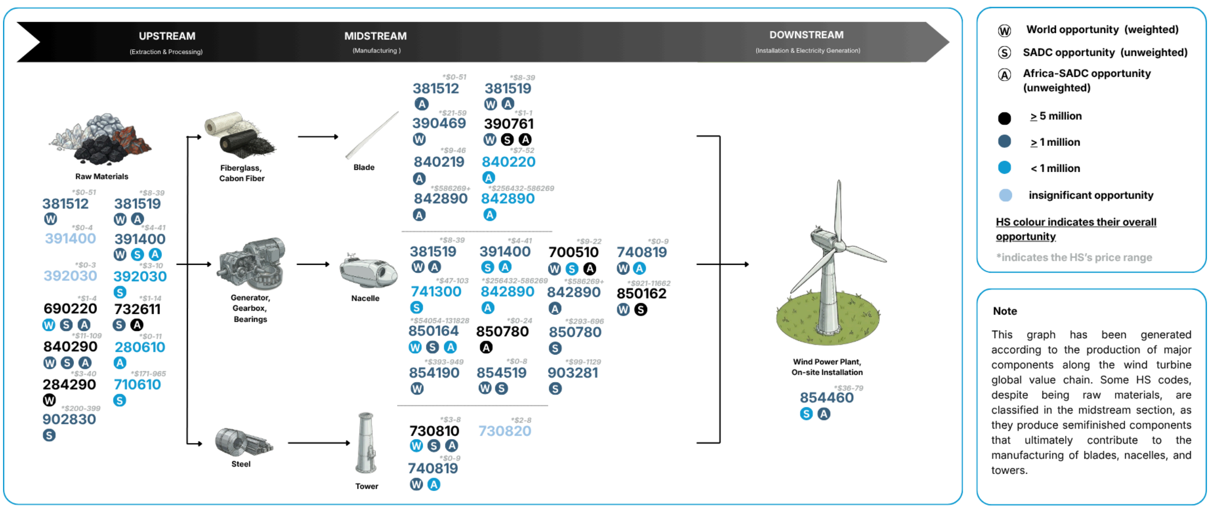
HS Code	Description (short)	Global market (2024)	Top exporters	Namibia current exports	Weighted world opportunity	Opportunity scenario share
HS 284290	Inorganic salts & peroxoacids	~US$2.50 bn	China 82%, Germany 5%, HK 4%, Korea 3%	~US$0.163 m (0.0065% world)	US$145.99 m	~6% world exports; ~2.2% of Namibia total exports

HS 284290 covers salts of inorganic acids or peroxoacids other than double or complex silicates, including aluminosilicates, excluding azides. Priced between US$3 and US$40 per kilogram, these chemicals function as generic inputs in thin-film solar technologies, semiconductor processes and lithium and other metal salts for solar-plus-storage applications.

Although Namibia's current exports are focused on industrial and agricultural salts – such as those produced by Walvis Bay Salt Holdings – at approximately US$0.163 million in 2024 (0.0065 per cent of world exports for this product), the weighted world opportunity of US$145.99 million points to meaningful headroom. In an opportunity scenario, HS 284290 in Namibia could reach approximately 6 per cent of world exports and 2.2 per cent of the country's total exports. The European Union provides a secure corridor for these high-grade processed goods, reinforced by the 2022 EU–Namibia partnership on sustainable raw materials.

A major barrier to entry is the high capital expenditure required for sophisticated chemical processing plants and the need for specialised human capital in chemical engineering. By establishing specialised industrial zones in Walvis Bay, or through entities such as the Namibia Investment Promotion and Development Board (NIPDB), Namibia can attract the investment needed to process its raw minerals into the high-purity salts required for the global solar industry, thereby increasing the domestic value-add of its mineral wealth. At the global level, this trade is driven by specialised inorganic salt and fine-chemical producers, including companies such as BASF (Germany) and a range of Chinese manufacturers supplying lithium and other high-purity salts for batteries, semiconductors and coatings.

Fig. 2 : Illustrative Overview on Wind Energy GVC Segments for Namibia



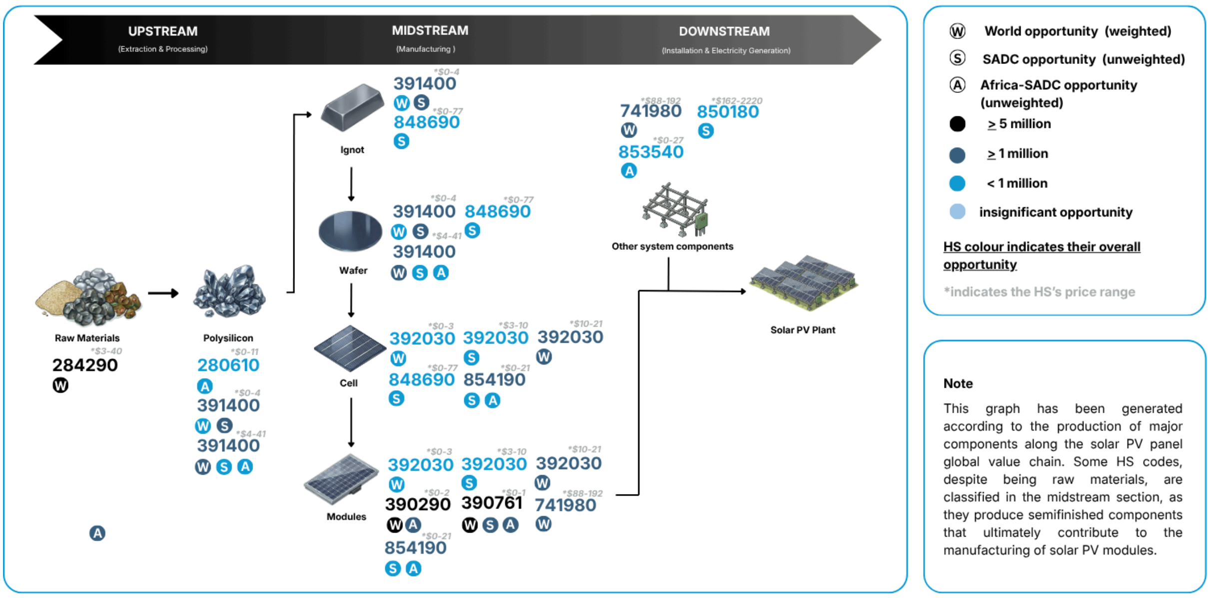
For wind energy, the same group of CETM-linked HS codes spans chemicals, steel structures, electrical machinery and advanced materials, reflecting the multi-stage nature of turbine and balance-of-plant manufacturing. Figure 2 highlights the specific products where Namibia holds meaningful export potential. Table 1 above summarises the core quantitative results for the key wind opportunity code.

HS 284290 inorganic salts (US$2.50 billion global exports in 2024, US$3–40 per kilogram) are used as inputs in resins and composite systems for blades, corrosion-resistant coatings for towers and foundations, and in process chemicals for metallurgical and surface-treatment operations in wind component manufacturing. Namibia's current exports of approximately US$0.163 million represent just 0.0065 per cent of world exports; the weighted global opportunity, however, implies a potential move to around 2.2 per cent of Namibia's total exports if this headroom were realised, illustrating how CETM-based chemical production can support both domestic wind project deployment and exports of intermediate inputs to regional markets such as the SADC and beyond.

Globally, demand for these salts is surging as offshore wind capacity expands across Europe and Asia. The requirement for deep-water logistical infrastructure and the complexity of meeting global purity standards for inorganic peroxoacids remain the most significant structural hurdles for new market entrants.

b. Zambia's Opportunities Along the Value Chains of Solar and Wind

Fig. 3 : Illustrative Overview on Solar (PV) Energy GVC Segments for Zambia



Zambia's solar value-chain opportunities are strongly linked to a set of HS codes that combine CETM-based inputs with downstream manufacturing potential. The infographic above (figure 3) maps the essential components and HS codes that define the solar energy supply chain. Table 3 provides a concise overview of the three highlighted codes; HS 284290 is then discussed in detail as a representative example.

Table 2. Zambia – Key solar and wind value-chain opportunities

HS Code	Description (short)	Global market (2024)	Top exporters	Zambia current exports	Weighted world opportunity	Opportunity scenario share
HS 284290	Inorganic salts & peroxoacids	~US$2.52 bn	China 82%, Germany 5%, HK 4%, Korea 3%	~US$567 (0.00002% world)	US$312.03 m	~12.4% world exports; ~2.767% of Zambia total
HS 390290	Propylene & other olefin polymers (primary forms)	—	—	—	~US$9.94 m	CETM-based input; downstream potential
HS 730810	Iron or steel structures and parts	—	—	—	~US$8.13 m	Turbine & BOP manufacturing input

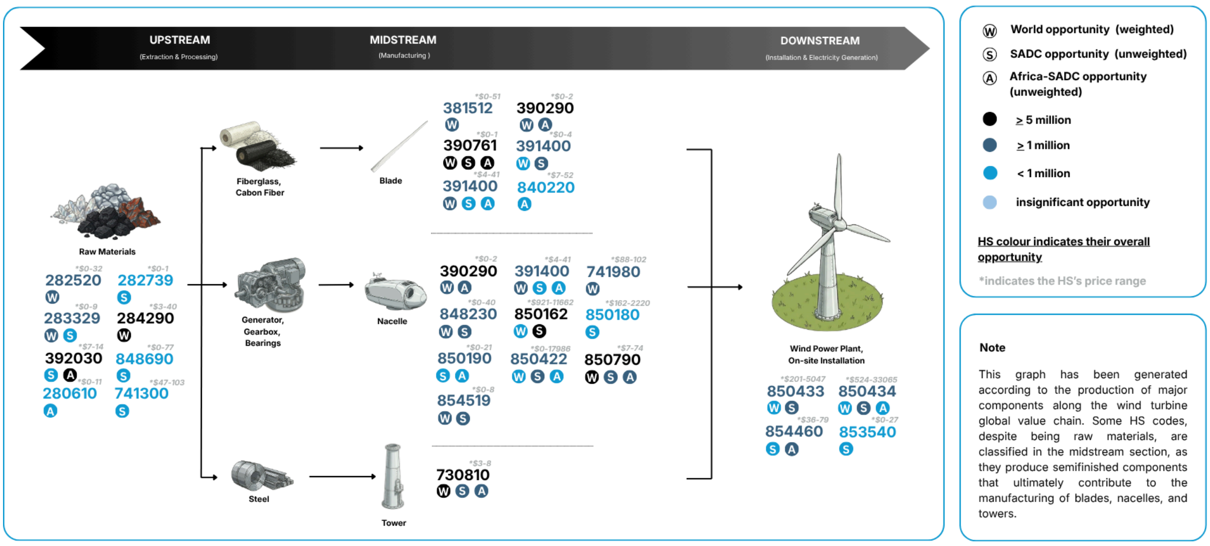
Among the codes in Table 3, HS 284290 – "Salts of inorganic acids or peroxoacids, other than double or complex silicates, including aluminosilicates, excluding azides" – stands out as the most quantitatively significant. The global market and opportunity metrics for this code are discussed in detail in the Namibia section above (Table 1).

Zambia's current exports of HS 284290 are still modest at around US$567 in 2024, equivalent to approximately 0.000005 per cent of total exports and 0.00002 per cent of world exports for this product. However, the weighted world opportunity is estimated at US$312.03 million, corresponding to a potential share of around 12.4 per cent of world exports and 2.767 per cent of Zambia's total exports in the opportunity scenario. The SADC and the Common Market for Eastern and Southern Africa (COMESA) provide secure regional export corridors, following recent trade agreements and regional integration initiatives.

A major barrier to entry is the high capital expenditure required for sophisticated chemical processing plants and the need for specialised human capital in chemical engineering. By establishing specialised industrial zones in the Copperbelt, or through entities such as the Zambia Development Agency (ZDA), Zambia can attract the investment needed to process its raw minerals into the high-purity salts required for the global solar industry. Companies such as Phisha Chemicals and Southern Bioenergy are starting to explore the industrial chemical space, but capturing the solar market will require significant investment in specialised R&D and a stable, low-cost electricity supply to power energy-intensive electrolysis and crystallisation processes. At the global level, key producers include BASF (Germany), Chemische Fabrik Budenheim (Germany), and a range of Chinese manufacturers supplying lithium and other high-purity salts for batteries, semiconductors and coatings.

For wind energy, a similar portfolio of HS codes connects Zambia's CETM resources and industrial base to key stages of turbine and balance-of-plant manufacturing. Figure 4 highlights the specific products where Zambia holds the most significant export potential. Table 2 above summarises the core quantitative results.

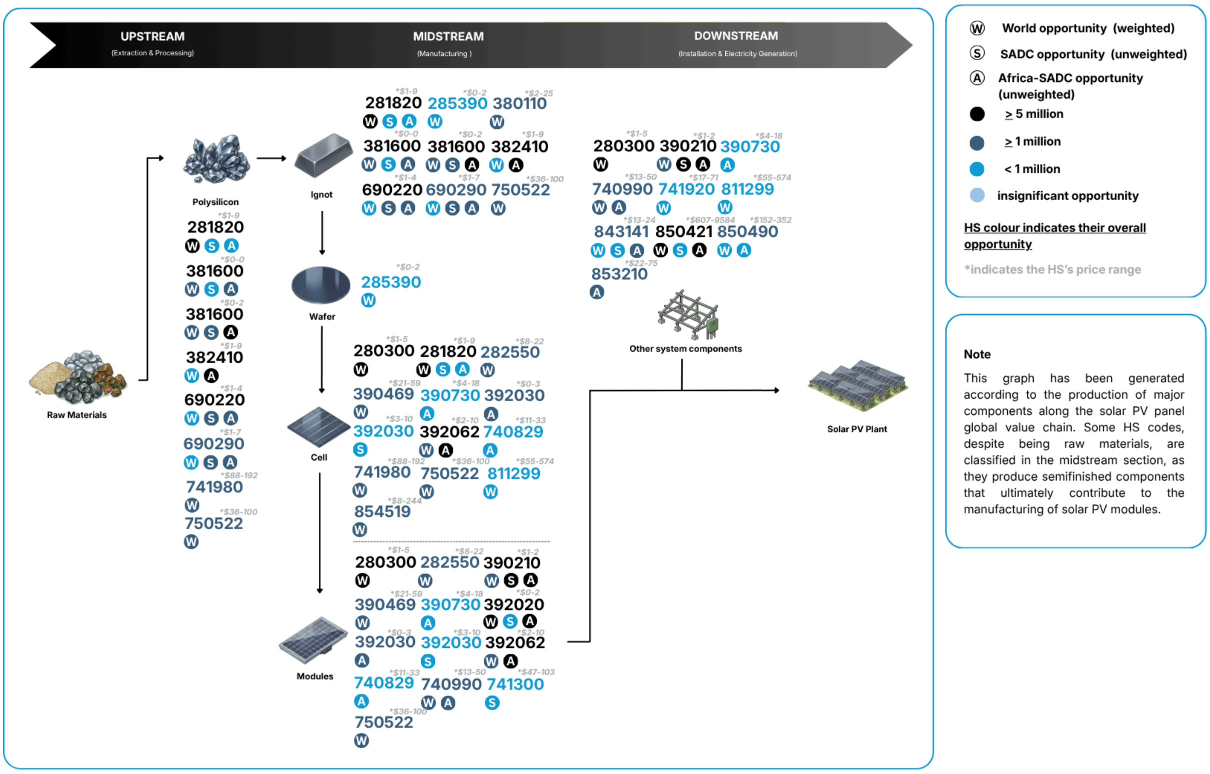
Fig. 4 : Illustrative Overview on Wind Energy GVC Segments for Zambia



HS 284290 again provides the most illustrative case. Globally, demand for these salts is surging as wind capacity expands across Europe, Asia and Africa, creating a lucrative export market for countries that can provide high-purity chemical inputs. The primary entry barrier remains the technological gap in producing semiconductor-grade inorganic salts that meet stringent international performance standards, as well as the complexity of deep logistical infrastructure. To pivot toward this high-value segment, Zambia must leverage its existing industrial chemical base while incentivising foreign partnerships to bridge the technical expertise gap, allowing the country to move away from the commodity trap and become a regional supplier of the high-tech chemicals that form the backbone of modern wind turbine electronic systems.

c. Madagascar’s Opportunities Along the Value Chains of Solar and Wind

Fig. 5 : Illustrative Overview on Solar (PV) Energy GVC Segments for Madagascar



Madagascar's highest export potential lies within the midstream segment of the solar value chain. Figure 5 maps the essential components and HS codes that define the solar energy supply chain. While a comprehensive analysis identified over 345 distinct commodities, the items highlighted represent the specific products where Madagascar holds the most significant export potential, for both regional and global markets. The value chain is segmented into three stages: upstream extraction and primary processing of raw mineral inputs (salts, aluminium); midstream industrial manufacturing (ingots, wafers, solar cells and modules); and downstream installation and generation. Table 3 below summarises the key figures for the three highlighted codes.

Table 3. Madagascar – Key solar value-chain opportunities

HS Code	Description (short)	Global market (2024)	Top exporters	Madagascar current exports	Weighted world opportunity	Opportunity scenario share
HS 392062	PET plates, sheets, film, foil & strip	~US$9.71 bn	China US$1.64 bn, Korea US$1.29 bn, Japan US$1.09 bn	~US$0 (negligible)	~US$4.07 m	~0.15% total exports; ~0.04% world
HS 392020	Polypropylene sheets, films & strip	~US$11.53 bn	China US$1.34 bn, Germany US$1.21 bn, Italy US$0.77 bn	~US$31,000 (0.0002% world)	~US$8.79 m	~0.34% total exports; ~0.076% world
HS 850421	Liquid dielectric transformers ≤650 kVA	~US$4.05 bn	Korea US$534 m, Mexico US$521 m, China US$505 m	US$0	~US$37.99 m	~1.446% total exports; ~0.91% world

Madagascar's emerging solar value-chain opportunities are increasingly anchored in intermediate goods that combine polymer-based components for PV modules with electrical equipment for power evacuation and grid integration.

PET films (HS 392062), priced around US$2–10 per kilogram, play a critical role as durable, transparent layers and backsheets in solar modules. Madagascar's current exports are negligible (approximately zero, with a small negative re-export adjustment of US$188), but a weighted world opportunity of approximately US$4.07 million suggests that if the country were to build basic film-extrusion and finishing capabilities, it could raise this product to approximately 0.15 per cent of its total exports and 0.04 per cent of world exports.

A similar dynamic applies to HS 392020. Polypropylene sheets and films (priced between US$0 and US$2 per kilogram) are widely used in packaging and industrial laminates, but also in PV module backing structures, cable insulation and auxiliary components for the balance of system. In an opportunity scenario, HS 392020 could reach roughly 0.34 per cent of Madagascar's total exports and 0.076 per cent of world exports. Leveraging existing experience in light manufacturing and export processing zones, Madagascar could develop polymer compounding and film-conversion facilities as an intermediate step towards more sophisticated solar materials.

The most striking quantitative gap emerges in HS 850421, which covers liquid dielectric electrical transformers with a rated capacity not exceeding 650 kVA – equipment central to connecting small and medium-scale solar installations, mini-grids and hybrid systems to distribution networks. Madagascar currently records no exports under this code, yet the world opportunity index of approximately 37.99 indicates the greatest scope of the three codes for both import substitution and export-oriented assembly. In an opportunity scenario, this product alone could reach approximately 1.446 per cent of Madagascar's total exports and approximately 0.91 per cent of world exports – a significant potential repositioning for a single industrial product line. Given the country's growing interest in renewable energy deployment and the need to expand rural electrification through solar mini-grids, local transformer assembly or partial manufacturing, possibly via joint ventures with established producers from Asia or Latin America, could become a strategic industrial niche.

Taken together, PET and propylene films (HS 392062 and HS 392020) offer lower-barrier entry points into solar-related materials, building on generic plastics processing that also serves packaging and other manufacturing sectors, while liquid dielectric transformers (HS 850421) sit closer to the power-system side of the solar value chain, where quality standards, engineering skills and capital requirements are higher but the unit value and potential export impact are substantial. By targeting these segments within dedicated industrial zones, aligning investment promotion through institutions such as the Economic Development Board of Madagascar, and linking local production to regional solar deployment in Eastern and Southern Africa, Madagascar could gradually transform its current marginal presence in these products into a measurable contribution to global solar value chains.

Within the wind value chain, Madagascar's greatest export potential lies within the nacelle component of the midstream segment. Figure 6 features key components of the wind supply chain, highlighting those with export potential. The wind energy value chain is divided into three segments: upstream extraction and processing of raw materials (salts, sulphates and polymers of propylene); midstream manufacturing and transformation into specialised components (blades, tower and nacelle including gearbox and bearing); and downstream installation and electricity generation. Table 4 summarises the core quantitative results for the two highlighted codes.

Fig. 6 : Illustrative Overview on Wind Energy GVC Segments for Madagascar

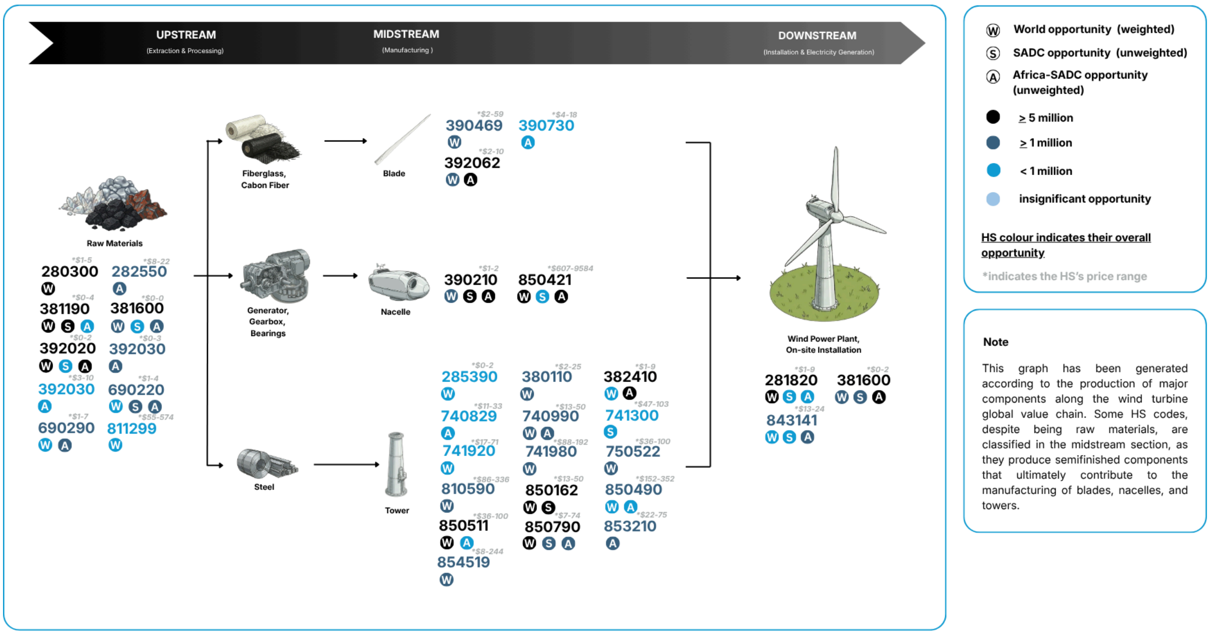


Table 4. Madagascar – Key wind value-chain opportunities

HS Code	Description (short)	Global market (2024)	Top exporters	Madagascar current exports	Weighted world opportunity	Opportunity scenario share
HS 850790	Parts of electric accumulators	~US$7.7 bn	China ~30%, USA ~30%	~US$0 (effectively zero)	~US$103.40 m	From 0% → ~4% of total exports
HS 850511	Metal permanent magnets	~US$5.13 bn	China ~60%	~US$384	~US$19.9 m	From ~0% → ~0.8% of total exports

A comparable portfolio of HS codes connects Madagascar's CETM resources, specifically its significant reserves of graphite, nickel and cobalt, to key components in energy storage and turbine drive-train manufacturing.

Parts of electric accumulators (HS 850790) are essential for the battery systems that stabilise wind power grids. The weighted global opportunity of approximately US$103.40 million points to massive headroom to establish a presence in the battery component assembly segment. If this potential were realised, HS 850790 could move from 0 per cent to an estimated 4 per cent of Madagascar's total exports.

Metal permanent magnets (HS 850511) are critical for the permanent magnet generators used in high-efficiency turbines. The estimated weighted world opportunity of approximately US$19.9

million represents a potential jump to approximately 0.8 per cent of total exports. This illustrates how Madagascar's CETM endowment, particularly in rare earth elements and battery minerals, can translate into quantitatively significant opportunities when paired with targeted investment in midstream processing.

Globally, demand for these components is surging as offshore and onshore wind capacity expands across Europe, North America and Asia. The requirement for sophisticated chemical-to-metal conversion facilities and the complexity of meeting international magnetic performance and battery-grade purity standards remain significant hurdles. The primary entry barrier is the technological gap in domestic value addition for magnet-grade materials. To pivot toward these high-value segments, Madagascar must leverage its strategic mineral wealth while incentivising foreign partnerships to bridge the technical expertise gap, allowing the country to move away from the commodity trap and become a specialised supplier of the high-tech components that form the backbone of modern wind energy systems.

APPENDIX C: Case Studies

a. Indonesia: A Strict Export Ban on Raw Nickel for Downstreaming Development

Indonesia's sequential export bans on raw nickel, initiated in 2014 and fully enforced by 2020, represent a state directed intervention designed to stimulate domestic industrial capabilities.[162] This strict trade friction imposed on unrefined minerals explicitly encourages the local economic diversification to midstream commodities through mandatory beneficiation. Serving as the dominant nickel supplier at 52 per cent of the global output, the country has been successfully capturing the escalating international demand for electric vehicle battery precursors, like Mixed Hydroxide Precipitate and nickel sulphate, predominantly driven by manufacturing powerhouse like China.[163] That said, Chinese enterprises have been relocating their nickel processing operations to Indonesia, investing heavily in High Pressure Acid Leach technology to refine domestic laterite ores to battery grade standards.[164] Such strategy yielded substantial financial gains, leading to over US$45 billion FDI in 2022, with the mining and basic metal industries contributing more than one third of this total, which has been further topped to US$53.4 billion by 2025.[165]

While the Indonesian's top-down industrial policy has succeeded in attracting foreign capital and accelerating supply chain development, it reveals significant vulnerabilities concerning social-environmental governance. Despite nominal workforce development programmes and university level knowledge exchange, core managerial control and technological intellectual property remain concentrated within foreign entities, constraining the accumulation of domestic industrial capabilities.[166] Scholars have further observed that close alliances between foreign capital and central government administration facilitates rapid policy execution, yet frequently marginalise local

[162]Bahlil Lahadalia, Chandra Wijaya, Teguh Dartanto, and Athor Subroto, "Nickel Downstreaming in Indonesia: Reinventing Sustainable Industrial Policy and Developmental State in Building the EV Industry in ASEAN," JAS: Journal of ASEAN Studies 12, no. 1 (2024): 79–106.
[163]International Energy Agency (IEA), Global Critical Minerals Outlook 2024, report (2024), 139–42, https://www.iea.org/reports/global-critical-minerals-outlook-2024.
[164] Richard Schodde and Pietro Guj, "Nickel: A Tale of Two Cities," Geosystems and Geoenvironment 4, no. 1 (2025): 100356, https://doi.org/10.1016/j.geogeo.2025.100356.
[165]Reuters Plus, "Indonesia's Half-Trillion-Dollar Move Up the Value Chain," Reuters, accessed April 13, 2026, https://plus.reuters.com/indonesias-half-trillion-dollar-move-up-the-value-chain/p/1.
[166] Ridha Amaliyah, "Chinese Investment, Social Relations, and Local Actors: The Case of IMIP in Central Sulawesi," WIMAYA 6, no. 2 (2025): 101–113, https://wimaya.upnjatim.ac.id/index.php/wimaya/article/view/20322.

communities from the decision making process.[167] This governance deficit is visible in documented cases of environmental degradation linked to nickel beneficiation, where regulatory enforcement has been inconsistent and community health risks inadequately overlooked.[168] The absence of robust, inclusive policy design erodes the industry's social legitimacy, generating reputational liabilities that threaten investment flows and long-term financial viability.

b. Chile: Lithium Industrialisation Stalled by Compounding Policy Misalignment

Chile's repeated failure to scale up lithium hydroxide production, a critical step toward high-performance battery manufacturing, suggests that concessional finance alone cannot sustain downstream industrial policy when a series of externalities spanning across geological, infrastructural, and market constraints remain unaddressed.[169] Despite accounting for roughly one-fifth of global lithium production,[170] the country's downstream industrialisation ambitions have recorded two consecutive policy failures between 2018 and 2025.[171] Generous market incentives are offered in forms of concessional pricing, whereby raw lithium was offered to foreign investors at rates within the lowest 20 per cent of the six-month average global price in exchange for local operations of value-added lithium commodities processing plants.[172] Policymakers initially prioritised lithium hydroxide production due to its significance in further downstreaming to high-performance batteries value chains.

Contractual ambiguity over the definition of value addition was further compounded by acute water scarcity in the arid Atacama region where lithium processing requires significant water inputs,

[167] Meditya Wasesa, Taufiq Hidayat, Dinda Thalia Andariesta, Alma Kenanga Attazahri, Bima Satritama, Haidar Aji Wasesa, Zulfiadi Zulhan, Mohammad Zaki Mubarok, and Utomo Sarjono Putro, "Navigating Trade Policies and Sustainability: A System Dynamics Analysis of Indonesia's Nickel Supply Chain," Resources Policy 112 (2026): 105786, https://doi.org/10.1016/j.resourpol.2025.105786.

[168] Hans Nicholas Jong, "Repeated Failures Expose Gaps in Indonesia's Nickel Waste Management," Mongabay News, April 13, 2026, https://news.mongabay.com/2026/04/repeated-failures-expose-gaps-in-indonesias-nickel-waste-management/.

[169] José Carlos Orihuela, Felipe Irarrázaval, and Cristián Flores, "Chile at the Green Window of Opportunity: The Troubled Road to New Productive Capabilities," Journal of Globalization and Development 16, no. 2 (2025): 277-300, https://doi.org/10.1515/jgd-2024-0090.

[170] Felipe Irarrazaval and Sebastian Carrasco, "One Step Forward, Two Steps Back? Shifting Accumulation Strategies in the Lithium Production Network in Chile," The Extractive Industries and Society 15 (2023): 101327,https://doi.org/10.1016/j.exis.2023.101327.

[171] Orihuela, Irarrázaval, and Flores, "Chile at the Green Window of Opportunity," 298.

[172] CORFO (Corporación de Fomento de la Producción), "Selection Process of Specialized Producers of Lithium Products with Added Value in Chile," government document (2022), accessed May 9, 2026, https://wapp4.corfo.cl/archivos/WCSCONTI/PG/1476733263212/CALLSelectionProcess.pdf.

rendering production cost unproductive for foreign investors.[173] Profit-making entities fail to proceed further battery plans given only baseline lithium carbonate production being initiated at end.[174] Despite in the second phase of the policy that launched in 2023 have clearly specified on the concessional access can only be tied to the production of more advanced downstream products, particularly lithium iron phosphate (LFP) cathode materials;[175] the sudden decline in global lithium prices from US$80,000 to merely US$10,000 per ton,[176] substantially eroded the value of the initial discount along with the obligations associated with community investment agreements, including requirements to hire a majority local workforce.[177] The rocketed operational constraints consequently encouraged investors to redirect capital toward less restrictive competitors such as Argentina and Brazil. That said, while Chile has remained successful in securing its position as a major lithium exporter, its midstream and downstream industrial ambitions have remained largely stalled.

c. Brazil: A Domestically Anchored Approach to Niobium Downstreaming

Brazil's niobium value chain demonstrates a viable pathway in accumulating industrial capabilities entrenched along downstream domestic industrial upgrading, which have been further reinforced by recent state-led industrial policy. Controlling over 90 per percent of global niobium production,[178] the country's value chain is anchored by Companhia Brasileira de Metalurgia e Mineração (CBMM), a locally owned private entity founded in 1955. Since its early mining operations when raw niobium ore had little recognised industrial application, a vertical integration manufacturing model has been adopted by developing production capabilities for high-value products like ferroniobium while building local R&D efforts in advancing and promoting niobium's usage.[179] By creating possible

[173] B. J. C. Guajardo, "Lithium in Chile: A Long and Complicated Journey," in Downstream Diversification of Mineral-Rich Countries: Challenges and Opportunities to Add Value in Energy Transition Supply Chains, ed. Tom S. H. Moerenhout and Juan Carlos Jobet (Springer, 2026), 127–144, https://doi.org/10.1007/978-3-032-06139-3_8.
[174] Guajardo, "Lithium in Chile," 143.
[175] Orihuela, Irarrázaval, and Flores, "Chile at the Green Window of Opportunity," 292.
[176] Petra Dünhaupt, Helena Gräf, Valeria Jiménez, and Benjamin Jungmann, "Industrial Policy Space in Emerging Economies: The Case of Chile's Lithium Industry and the Energy and Raw Materials Chapter in the EU-Chile Free Trade Agreement," Working Paper No. 251/2025 (Berlin: Institute for International Political Economy, Berlin School of Economics and Law, 2025), https://hdl.handle.net/10419/313641.
[177] Guajardo, "Lithium in Chile," 137.
[178] Piergiuseppe Fortunato and Clovis Freire Junior, Critical Minerals, Critical Decisions: Industrial Policy for the Energy Transition, UNCTAD, 2026, https://unctad.org/system/files/official-document/gds2025d5_en.pdf#:~:text=It%20should%20aim%20to%20foster,minerals%20for%20structural%20transformation%20and
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applications and facilitating export for this specific mining industry, current applications varies from energy, medical appliances and aerospace manufacturing value chains,[180] with the local export for Ferroniobium has surged over 30 fold from 1975 to 2023.[181] Of note, this particular mineral is also known as advancing battery longevity and safety while strengthening the manufacturing components of both solar and wind energy plants components.[182]

Having achieved sustained financial success, CBMM has been consistently reinvesting the local economy by setting up domestically located R&D and series of educational and vocational training programmes whilst retaining majority Brazilian ownership over strategic and technological decisions.[183] In particular, foreign capital was only admitted as a minority partnership, with Chinese and Japanese–South Korean consortia each holding 15 per cent stakes, expanding market access without transferring operational or technological control abroad.[184] Whilst Brazil's niobium downstreaming success is driven primarily by commercial practices, the launch of Nova Indústria Brasil in 2024 signals an emerging attempt to institutionalise analogous practices at scale with financial support on developing local CETM value chains.[185] In this regard, Brazil practices demonstrate a viable option for minerals-rich economies to achieve genuine value addition in the CETM value chain without surrendering productive control to foreign investors, from processing minerals domestically from the outset, reinvesting the capital gain into local R&D and community development along with a structured foreign engagements as conditioned minority partnership.

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ANNEX A: Harmonised System Codes Lists - Mapping Solar PV and Wind Value Chains

Annex A presents the HS code lists used to map the value chains of the two renewable energy technologies addressed in this report: solar PV and wind energy. The annex identifies the traded goods, ranging from raw materials and intermediate inputs to manufacturing equipment, components, and balance-of-system elements, that are relevant to each technology's production and deployment chain. Each HS code is accompanied by its sector classification, the HS Nomenclature 2022 definition, a concise product description, and the value chain stage to which it corresponds. From the following page, the two lists are presented in full: first the solar PV value chain HS code list, followed by the wind energy value chain HS code list.