August 2023

Critical Minerals and Routes to Diversification in Africa: Opportunities for Diversification into Renewable Energy Technologies - The Case of Morocco

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Background paper commissioned by the UNCTAD secretariat for the 2023 edition of the Economic Development in Africa Report

Abstract

This paper maps the emerging opportunities and challenges for diversification into renewable energy technology value chains and develops a framework that analyses how Morocco can potentially localise and capture value within these supply networks, including leading the building and development of renewable energy technology regional value chains. In doing this, we develop an in-depth country case study and highlights Morocco's routes to diversification, including opportunities for regional coordination and industrial development. The industrial policy lessons for productive transformation across Africa are discussed based on the empirical and sectoral-specific case studies.

Acknowledgement: We are grateful to Anja Slany and Habiba Ben Barka from UNCTAD for their invaluable conversations, guidance, and feedback in drafting the background papers. We also thank Gideon Ndubuisi and Rex Asiama for their insightful contributions and assistance in developing several parts of this paper.

Contents

1. Introduction

Over the last two decades, Morocco has witnessed a significant structural transformation of its economy and has become the most dynamic investment hub for medium-high tech industries in Northern Africa. This structural transformation has been driven by a significant acceleration in foreign and domestic investments in the automotive, aerospace, and renewable technology sectors, as well as chemicals.

According to the Moroccan Promotion Agency[1], the automotive industry is the first one in Africa for volume, with a production capacity of over 700,000 vehicles a year, and accounts for over $ 8 billion in export turnover with over 250 companies, including leading global players Renault and Stellantis Group. In the aerospace industry, leveraging production capabilities complementary to automotive, Morocco has also developed a solid manufacturing base for metal parts and sub-assembling of aircraft engines, machined and sheet metal parts, interior equipment, and composite parts.

As for the chemical and related industries, Morocco has become the second largest producer of pharmaceutical products in Africa in terms of volume, and it serves 65% of the country's needs. Furthermore, leveraging its phosphate rock reserves, over 70% of the world stock is in Morocco, the country has become the fourth largest exporter of fertilizers in the world. Phosphorus is essential for all food crops, in fact all plant life. This makes Morocco a gatekeeper of global food supply chains, and a major strategic supplier in the African market (Tanchum, 2022). In 2020, Morocco's state-owned company The Office Chérifien des Phosphates [Office of Moroccan Phosphates] (OCP) supplied 54% of all fertilizers in Africa, and accounted for over 90% of all fertilizers imported by the biggest African economy, Nigeria.

The proximity to the EU market and domestic political stability have played an important role in attracting FDIs into these sectors. In the MHT sectors, specifically, Morocco has high levels of GVC integration and domestic value addition in 2015, as reflected in the figure 1.

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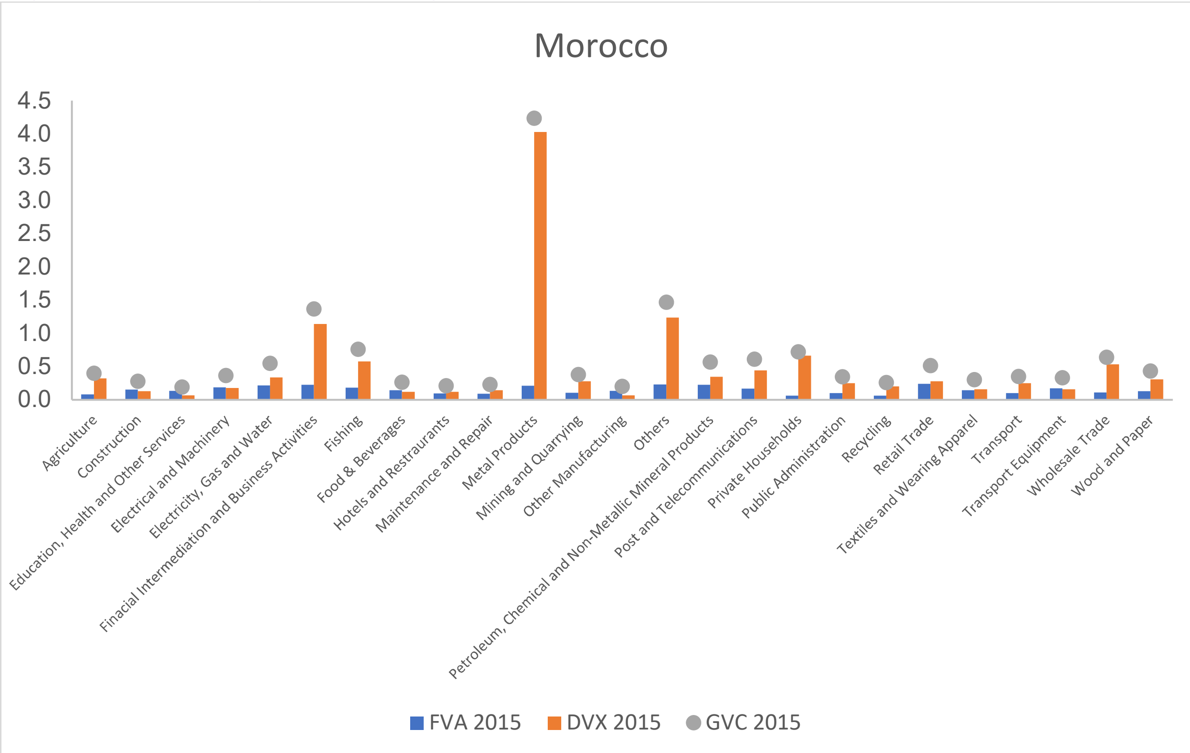
[1] Morocco Now

Figure 1: GVC integration, foreign and domestic value addition in Morocco, 2015.



Source: Authors based on EORA data

To further understand the emerging opportunities and challenges for diversification into renewable energy technology value chains, the paper develops a framework that maps the renewable energy technology value chain and analyses how Morocco can potentially localise and capture value within these supply networks, including leading the building and development of renewable energy technology regional value chains.

The remainder of the paper is structured as follows. Section 2 sets the scene by discussing the renewable energy transition in Morocco. Based on several sources of data, section 3 presents and discuss the role critical minerals could play in deepening Morocco's industrial diversification and technological capabilities development in the renewable energy sector. Section 4 concludes the paper with policy recommendations.

2. Energy transition in Morocco

The transformation of the energy sector towards renewable technologies has been a major enabler of the Moroccan structural transformation and diversification story. Despite its huge natural endowment in wind, solar and hydropower, for a long time Morocco has been a major energy importer, one of the largest in the region. However, over the last two decades the country has shown impressive growth of renewables to reach almost two-fifths of its electricity capacity. Morocco's development of renewable energy capacity is the result of the government ambitious long-term strategy as well as significant FDIs. The increasing creation and availability of renewable energy capacity has played a catalytic role in the country, with potential further diversification opportunities in the renewable technology value chains (vertical) as well as structural transformation across sectors (horizontal).

Morocco's national action on climate change dates back to the mid-2000s, when the country made the decision to become a regional leader in clean energy and to push forward massive renewables projects. In 2009, Morocco set out an ambitious energy plan – i.e. The 2009 National Energy Strategy – which aimed for 42% of total installed power capacity to be renewable energy by 2020. This was expected to require the commissioning of new plants to bring the total capacity to 2000 MW of solar, 2000 MW of wind and 2000 MW of hydro by 2020. The policy relied on an ambitious energy subsidy reform, complemented by framework of incentives and regulations to promote renewables. The government encouraged private-sector investments, through (i) increasing the installed capacity threshold of hydro projects; (ii) allowing renewable electricity producers access to the low voltage, the medium, high, and very high voltage electricity networks, and (iii) allowing the sale of excess electricity from renewable sources to the National Electricity and Water Utility– Electricity Branch (ONEE) for the facilities connected to the high and very high voltage networks (World Bank, 2018).

While Morocco missed its 2020 target – it managed to get to 20% of renewable capacity – the country managed to drive a strong expansion of both wind and solar during the 2010s, with solar photovoltaic (PV) capacity increasing 16-fold (albeit from a low base) and wind six-fold by 2020.[2] Morocco also made a massive effort in developing Concentrated Solar Panel (CSP) capacity in the country, which resulted in the country becoming the fifth in the world in 2021 with 1354 MW of installed capacity and an almost 20% annual rate of growth (ENI, 2022). The three-plant Noor-Ouarzazate CSP complex, at the time the world's largest CSP plant, epitomised Morocco's effort in renewables development.[3] The complex spreads over 3,000 hectares and uses innovative methods to generate and store the sun's rays. Indeed, by combining CSP with thermal storage technologies, it is possible to provide reliable power even when the sun is not shining. Given these properties, the IEA (2014) estimates that up to 11 percent of the world's electricity generation in 2050 could come from CSP.

Over the past two decades, investment in renewable energy grew rapidly. Yet of the USD 2.8 trillion invested globally between 2000 and 2020, only 2% went to Africa (around USD 55 billion), despite the continent's enormous potential to generate energy from renewable

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[2] https://www.bbc.com/future/article/20211115-how-morocco-led-the-world-on-clean-solar-energy

[3] https://www.worldbank.org/en/news/press-release/2016/02/04/worlds-largest-concentrated-solar-plant-opened-in-morocco

sources. In African countries such as South Africa, Egypt, and Morocco, the large bulk of investments in renewables picked up in the 2010s, driven by structured renewable energy procurement programmes. They include feed-in tariffs schemes and auctions supported by development finance institutions and multilateral development banks (IRENA, 2022).

Investments remained concentrated in a few regions and countries, Morocco being one of them. In North Africa, over the 2010s, investments totalled USD 17.5 billion and were concentrated in Morocco (USD 9.5 billion) and Egypt (USD 8.2 billion). Investments were concentrated in solar (PV and thermal) (67.5%) and wind (32%), with the remainder going to bioenergy and small hydropower. The Southern Africa region attracted USD 22.4 billion, over 40% of total flows over the decade and concentrated in South Africa. Thanks to its Renewable Energy Independent Power Producer Procurement Programme (REI4P), South Africa took in 85% of the region's investment between 2010 and 2020. Solar (PV and thermal) projects accounted for 60% of that investment (USD 13.5 billion) followed by wind at 35% (USD 7.8 billion) (figure 2).

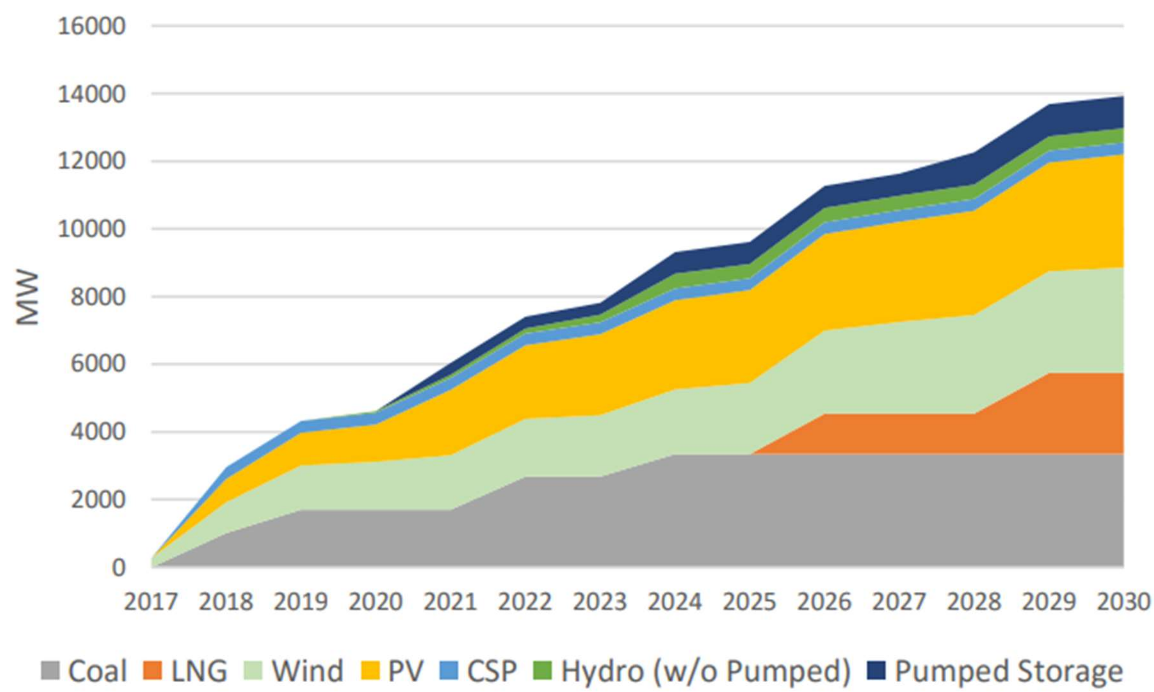
Figure 2: Top recipient of renewable investments (2a) and off-grids investments in Africa in constant 2019 USD millions (2b), 2010-2020.

Sources: Figure 2a - BloombergNEF (2021) and Figure 2b - Wood Mackenzie (2021) as cited in IRENA (2022).

The peak in renewable energy investment was reached in 2018 and driven by large investments in solar photovoltaic (PV), solar thermal and wind, with at least 3 gigawatts (GW) of new capacity added in 21 countries. Almost half of that investment went into Morocco (AfDB, 2019). Wind investments in 2018 were valued at USD 4.2 billion; 18 new windfarms totalling at least 1.3 GW were concentrated in six countries, South Africa the first among them at USD 2.6 billion. Solar thermal investments – mainly concentrated solar power (CSP) – were focused in Morocco and South Africa, especially between 2012 and 2018. They included a USD 2.4 billion investment in Morocco's Noor PV-CSP hybrid plant (about 300-390 MW in capacity) in Midelt in 2018. Previously, following the financial close of Morocco's Noor CSP project (160 MW) in Ouarzazate in 2012, the project was expanded to an additional 350 MW of generation capacity through an investment of USD 2.1 billion in 2015 (BloombergNEF, 2021).

In 2015, during the 21st session of the UNFCCC's Conference of the Parties (COP21), Morocco announced a further planned increase in the renewables capacity to reach 52% of the total by 2030 (20% solar, 20% wind, 12% hydro) (figure 3). To meet this new target, Morocco needs to create 10 GW of extra renewable capacities, with an announced capacity target of 4560 MW of solar, 4200 MW of wind, and 1330 MW of hydropower. The achievement of these ambitious goals requires a massive investment in solar power – both panels and solar batteries – and wind technologies. Both technologies are currently largely imported by Morocco, despite the fact that the country has several critical minerals such as cobalt and phosphate rock which are essential to manufacture them. These critical minerals are also key to manufacture functional elements of digital technologies, as well as components for key sectors in which Morocco has moved in, that is, automotive and aerospace. The automotive sector, in particular, is undergoing a dramatic transformation from fossil fuel-based engines to renewable fuels and electric vehicles.

Figure 3: New commissioned and proposed plants in Morocco between 2017 and 2030



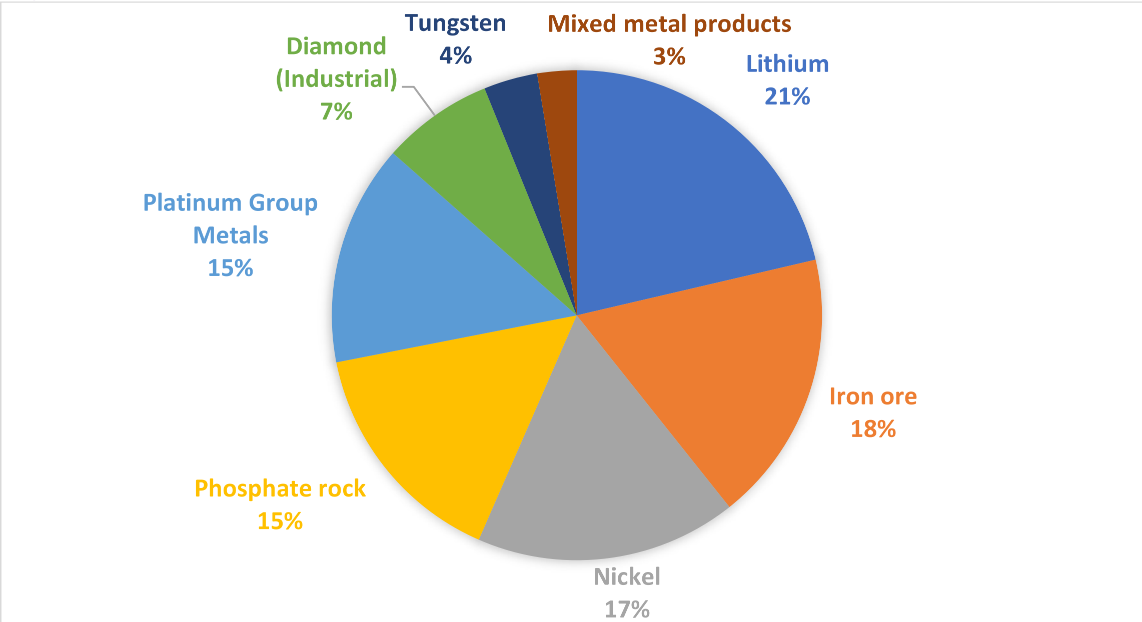
Source : ONEE—Schéma Directeur Production 2017-2030, as cited in World Bank (2018)

3. Critical minerals in Morocco: pivot for industrial diversification and technological deepening

The mineral sector is the main foreign exchange earner for the Moroccan government, and phosphate rock mining and the phosphate-based products industry continued to be a major source of exports. Morocco is the second producer of phosphate rock in the world after China. Morocco, however, is also a major producer and exporter of other critical minerals. According to the USGS Latest Report on Morocco and Western Sahara Minerals (USGS, 2022), Morocco was the 11th-ranked and 17th-ranked producer of cobalt and silver, respectively, and accounted for 1.8% and 1.4% of world output, respectively. Morocco also accounted for 1.4% of the world's copper production. Other mineral commodities produced in Morocco included arsenic trioxide, cement, clays (bentonite, fuller's earth, and montmorillonite), feldspar, gold, iron ore, lead, manganese, mercury, natural gas, nickel, petroleum condensate, salt, and zinc. The growth of Morocco's cobalt sector will attract interest from mining and automotive companies in the short term (2022-2026), posing an upside to the development of Morocco's local EV supply chain. The country has also the 11th largest cobalt reserves globally.

As for its export basket, eight critical minerals account for 97% of its value export (figure 4). Lithium is the first critical mineral in terms of export value and accounts for 21% of the critical mineral export basket, followed by iron ore (18%), nickel (17%), phosphate rock (15%), and PGM (15%). The entire share of iron ore, nickel and PGMs is exported outside Africa, while lithium and phosphate are exported to Africa (7% and 10% respectively). Most of the production and export of these minerals is due to two major groups – OCP and Managem. The state-owned OCP is the main company responsible for phosphate rock mining and phosphate-based fertilizers and other products manufactured in Morocco (OCP Group, 2018). OCP has invested in expanding capacity at existing mines, adding new mines, and adding new concentrating, floating, and washing units. Managem S.A., a group of companies publicly listed on the Casablanca Stock Exchange, is the leading mining company in Morocco with almost 6,000 employees and a wide portfolio including cobalt, copper, lead, nickel, and zinc; precious metals, such as gold and silver; and industrial minerals, such as arsenic, and fluorspar (Managem S.A., 2018). Managem conducts mineral exploration, marketing, processing, and services through its subsidiaries, including mining development projects in African countries such as Burkina Faso, the Democratic Republic of the Congo [Congo (Kinshasa)] (Lamikal S.A.), Côte d'Ivoire (Managold Ltd.), Ethiopia, Gabon (Managem Gabon), Guinea (Société des Mines de Mandiana, Guinée (SMM Guinée), and Sudan (Manub Mining Company Ltd. and MCM Soudan). Managem is focusing on increasing its output of cobalt cathode, copper concentrate, and Silver, also leveraging African wide regional value chains and shares in mining sites across the continent, such as the Pumpi Mine in Congo (Kinshasa).

Figure 4: Critical minerals export basket, Morocco, 2021



Source: Authors based on UNCOMTRADE.

The Moroccan government reformed in the mining sector regulatory and policy framework in 2015 in view of attracting foreign investments, increasing domestic value addition and boosting exports. Alongside incentives for mining companies, such as tax exemptions on imported equipment for investments, and reduced tax rate for companies that supply ores to domestic mineral-processing and beneficiation companies, Morocco has been increasingly looking at new diversification roots and markets that the country could pursue and target by leveraging its critical minerals.

3.1 Diversification route 1: From adopter to producer of solar and solar battery technologies

Morocco's domestic demand for solar panels and batteries is expected to increase dramatically, given its ambitious 2030 targets. Despite slow diffusion and uptake of solar technologies across Africa (see figure 5 below), in countries like South Africa, Morocco and Kenya, governments are increasingly turning to solar photovoltaics (PV) to bolster energy security and support economic growth in a sustainable manner. Hence there is a growing demand at the continental level.

Governments are also targeting competitive installed cost levels that are comparable to today's lowest cost projects, and hope to gain from overall reduced costs (IRENA, 2019). Economies of scale and continuous innovation throughout the solar PV supply chain have played a key role in reducing manufacturing costs at every step of the production process, but they have also reduced profit margins and increased entry barriers in the industry, and concentration.

Figure 5: Solar Power Capacity in Africa 2005-2021

Countries(*)

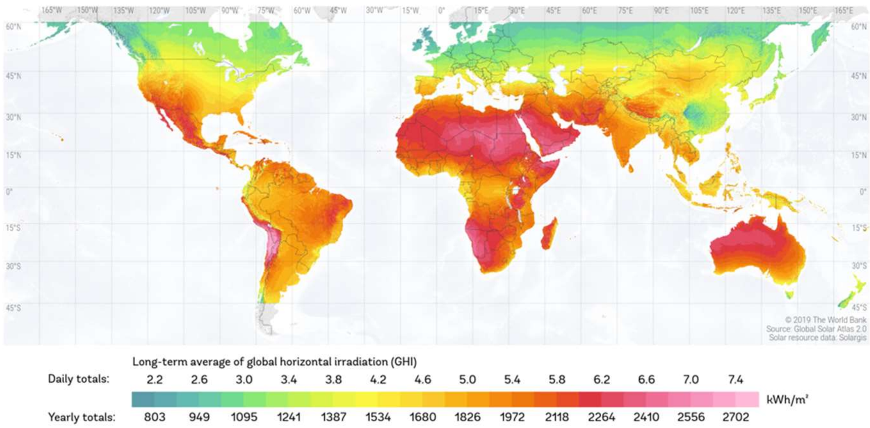
(MW)

		2005	2010	2015	2016	2017	2018	2019	2020	2021	Δ y/y (2021-2020)	CAGR (2021-2010)
Africa		26	194	1,931	2,988	4,711	7,211	8,417	9,708	10,308	6.2%	43.5%
Algeria				49	219	400	423	423	423	423	0.0%	
Angola		1	7	13	13	13	13	13	13	13	0.0%	5.9%
Benin				1	3	3	3	3	3	3	0.0%	
Cameroon		0	1	7	9	12	14	14	14	14	0.9%	27.5%
Chad			0	0	0	0	0	0	1	1	0.0%	70.9%
Congo				0	0	1	1	1	1	1	0.0%	
Côte d'Ivoire		0	2	5	5	8	13	13	13	13	0.0%	21.4%
Dem. Rep. Congo				1	3	5	20	20	20	20	0.0%	
Egypt		1	15	16	39	160	744	1,627	1,655	1,656	0.0%	53.4%
Equatorial Guinea										0		
Ethiopia			0	10	14	12	12	12	20	21	5.0%	82.7%
Gabon	0	1	1	1	1	1	1	1		1	0.0%	0.0%
Ghana			31	38	47	78	85	108		108	0.0%	
Kenya		0	0	30	31	38	105	106	106	147	38.7%	82.5%
Libya		1	4	5	5	5	5	5	5	6	23.9%	5.0%
Madagascar		0	2	9	11	13	33	33	33	33	0.0%	32.4%
Mauritania				18	35	35	87	88	88	88	0.0%	
Morocco		10	14	20	22	24	194	194	194	234	20.8%	29.6%
Mozambique				10	13	15	55	55	55	55	0.0%	
Namibia		2	4	21	36	75	93	145	145	145	0.0%	38.0%
Niger		1	2	7	8	9	27	27	27	27	0.0%	26.2%
Nigeria				17	18	19	19	28	28	33	14.9%	
Rwanda			0	14	19	28	38	38	38	38	0.0%	57.7%
Senegal		2	3	9	42	107	148	171	171	238	38.9%	47.6%
Sierra Leone		0	0	0	0	4	4	4	4	4	0.9%	41.9%
Somalia				0	5	7	7	7	16	24	51.5%	
South Africa			2	1,252	1,974	3,147	4,401	4,405	5,490	5,721	4.2%	106.6%
South Sudan				0	0	0	1	1	1	1	53.1%	
Sudan		0	2	20	26	36	59	80	117	136	16.0%	45.1%
Tanzania			0	13	19	22	26	24	24	24	0.0%	82.8%
Tunisia		1	2	28	38	47	64	80	95	95	0.0%	43.3%
Uganda		3	15	22	24	44	67	77	87	92	5.1%	18.0%
Zambia				0	0	0	1	96	96	96	0.0%	
Zimbabwe			0	4	5	6	11	16	18	30	64.2%	139.7%
Others Africa		4	118	296	311	368	443	523	597	768	28.6%	18.6%

Source: ENI, 2022

Mini grids powered by solar PV have attracted significant attention, and their cost structure is becoming more competitive, also thanks to new business models. In Africa, however, these systems remain relatively small, typically under 100 W, and require batteries and charge controllers to ensure stable output (IRENA, 2016). Solar batteries demand is therefore expected to rise as well. From a supply/production perspective, when it comes to solar energy generation, Africa is a global superpower. As shown in figure 6, most African countries have a competitive advantage given their highest horizontal irradiance levels, hence the potential highest level of energy productivity of solar panels installed in the continent.

Figure 6: Global Horizontal Irradiation



Source: https://globalsolaratlas.info/download/world

Two main technologies currently dominate global solar PV markets and supply chains:

- crystalline silicon (c-Si) modules account for over 95% of global production;
- while cadmium telluride (CdTe) thin-film PV technology makes up the remaining.

The manufacturing of the physical components of which solar panels and solar storage are made of relies on a combination of a variety of metals, metalloids, non-metallic minerals and polymers, with material needs differing across technologies and segments. Critical minerals and rare earth elements needed include: Aluminium, Cadmium, Copper, Gallium, Indium, Lead, Molybdenum, Nickel, Silicon, Silver, Selenium, Tellurium, Tin, and Zinc. These minerals are deployed at different stages of the solar PV value chain (see figures 7 a and b below). Over the last decade, China has furthered gained leadership as manufacturer of wafers, cells and modules, while its share of global polysilicon production capacity almost tripled.

Overall, China controls 80% of all manufacturing stages globally. China has practically no competition in wafers, while for cells and modules manufacturing capacity has developed in Viet Nam, Malaysia and Thailand. As for polysilicon, Germany is still a major supplier for the c-Si PV modules industry, and Japan and the US supply semiconductor-grade products. Finally, China also dominates the module components industry, including glass, EVA, backsheet, and junction box (IEA, 2022).

Figure 7a: Key stages in the main manufacturing process for solar PV

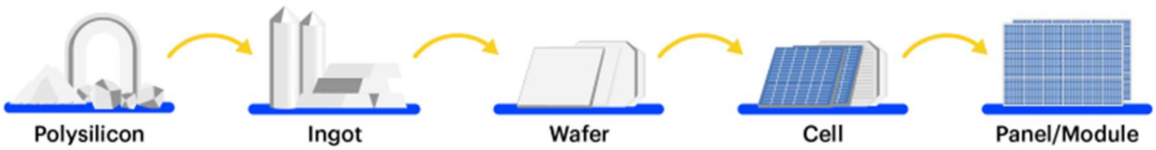
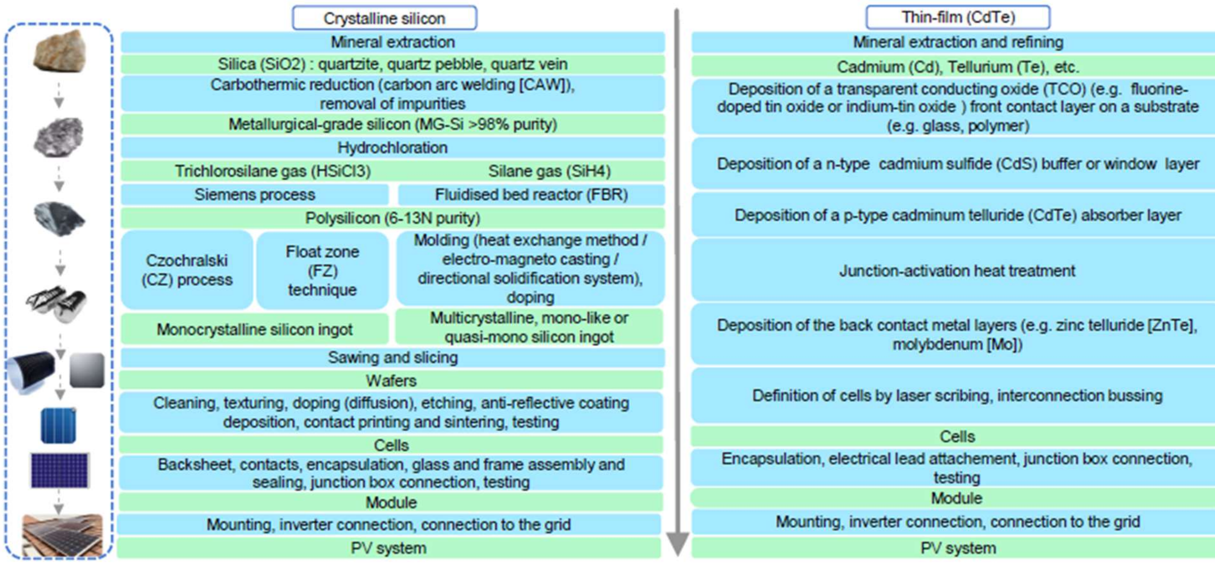


Figure 7b: Simplified manufacturing from raw materials for c-Si and CdTe solar PV systems



Source: IEA, 2022

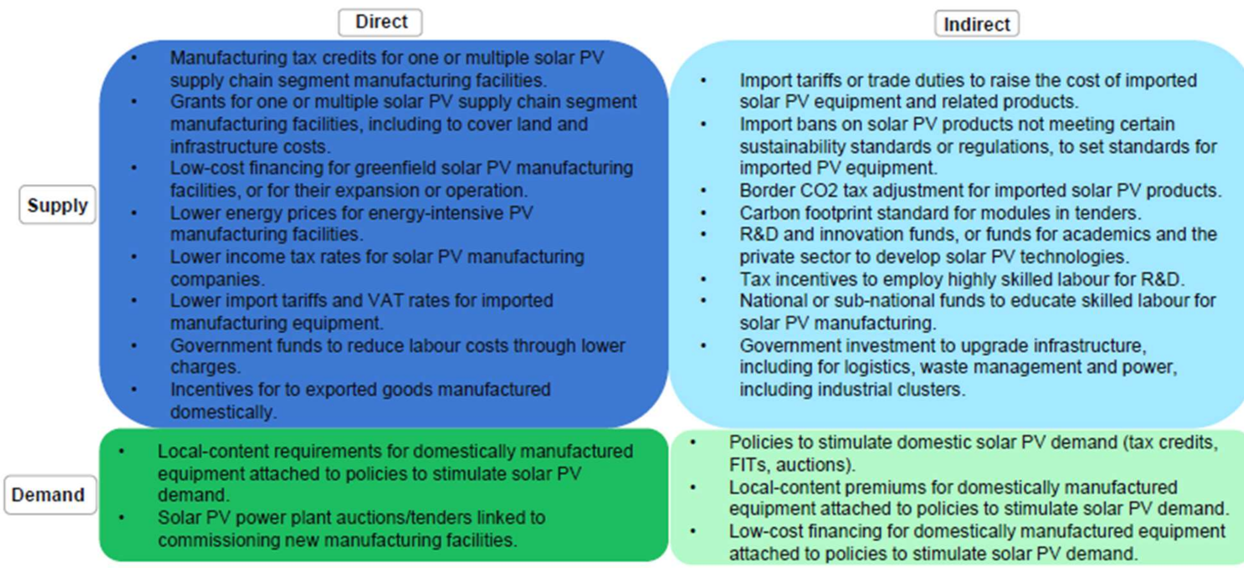
Production of solar PV is extremely limited in Africa, with some initial opportunities materialising in South Africa, Morocco and Egypt, also the countries with strongest demand pull. These countries can leverage their critical minerals which make up 35-50% of the total cost of a solar PV module at 2021 prices (IEA, 2022). Despite this important advantage, entry and diversification into the solar PV supply chain depends on several factors, such as technological capabilities, investment scale to be cost-competitive and financial requirements to support long term investments and risks. Jobs creation potential, recycling costs and infrastructural uptake bottlenecks are other important considerations.

From a technological capability perspective, chemical complexity, and skills requirements, Morocco and other countries interested in entering solar PV value chain might want to start from cell manufacturing and module assembly steps. From a technological point of view – high energy requirement – and financial perspective – high investment requirements and risks – manufacturing of polysilicon, ingots and wafers are among the most challenging stages in the solar value chain. Diversifying into solar PV manufacturing competitively also means reaching scale-investment thresholds. For example, greenfield polysilicon plants are not usually bankable for capacities of less than 10 000 Mt (around 3 GW). In China, plants size ranges from 40 000 Mt to 100 000 Mt (IEA, 2022).

For many African countries, this is not simply a financial challenge, but also an organisational capability one. Morocco, with its large corporations, experience in mega-project management and finance, and a robust regulatory framework, has a competitive advantage in this area and could attempt to diversify into some of these most complex segments of the value chain once has completed its scaling up of cell manufacturing and module assembly capacity. Government's strategic support through direct and indirect interventions on both supply and demand side would be however needed to crowd-in investments in such mega-projects (see Andreoni et al., 2022, for a case study in South Africa).

Figure 8 states the direct and indirect policies for solar PV manufacturing investments.

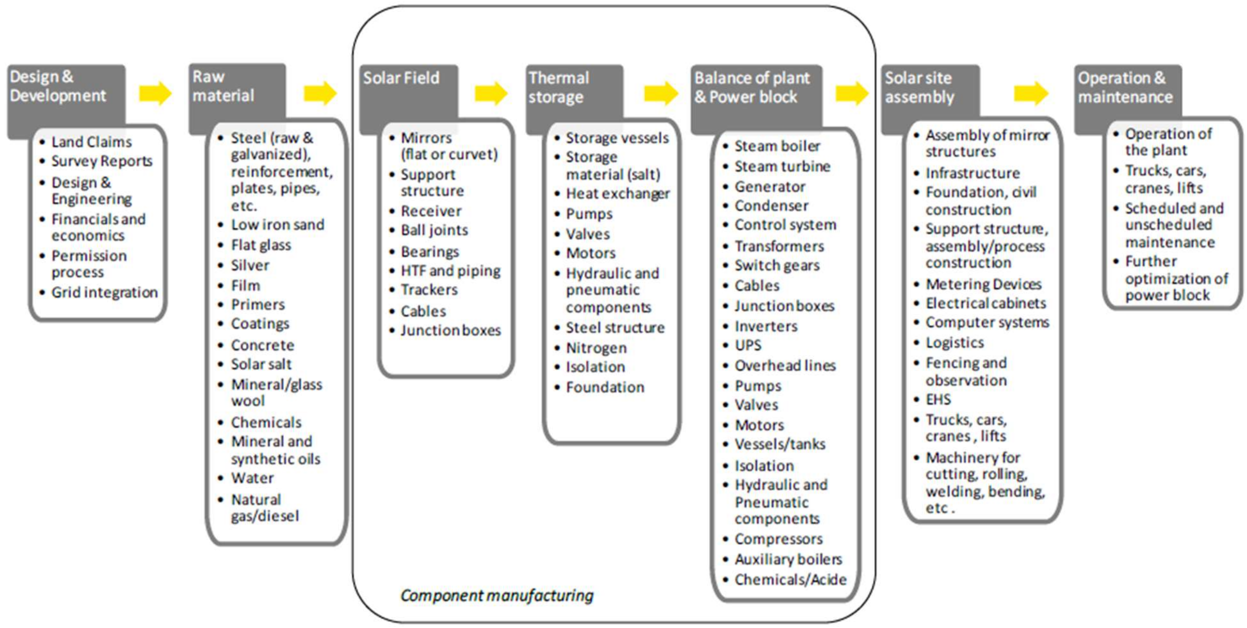
Figure 8: Policies for solar PV manufacturing investments



Source: IEA, 2022

Morocco has also developed significant capabilities in the deployment of CSP technologies as shown in figure 9. CSP value chain includes several industrial sectors supplying components to its three main segments: (a) the solar field with the mirrors and the solar receiver; (b) the thermal storage system as buffer storage for a heat surplus and (c) the power block for the electricity production. The three main technologies involved in CSP – tower, parabolic trough and linear-Fresnel – are made of mostly non-specialised components which could be manufactured in Morocco. Given a certain degree of technological relatedness, several first and second tier suppliers of the automotive and aerospace industries in Morocco could diversify into manufacturing components for CSP. As for the most complex and specialised components, like the mirrors or the heat exchangers, Morocco could attract investments and establish join ventures to transfer technologies and developed a skilled workforce. Finally, given that most value of the CSP-plant is generated in the construction phase, there are great opportunity for local content.

Figure 9: CSP technology supply chain



Source: EIB, 2015

3.2 Diversification route 2: Electric vehicles battery and circular economy

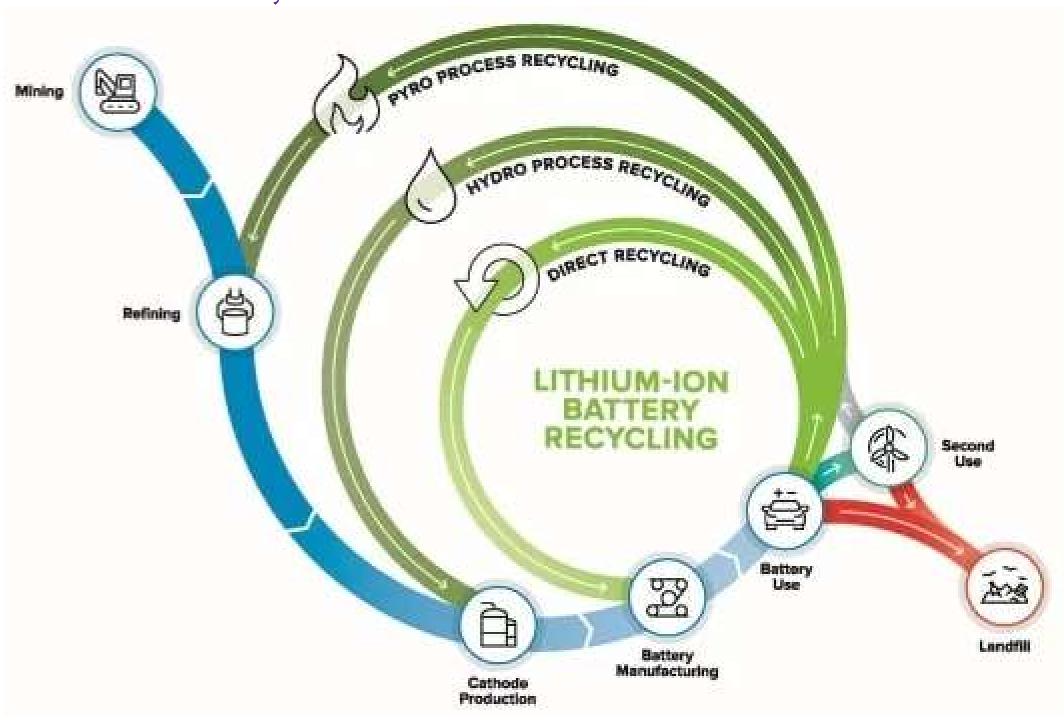
The Moroccan industrial-mineral complex – specifically its mix of a well-developed automotive sector and the availability of critical minerals essentials for batteries – is another important diversification route. This route involves both lateral diversification and opportunities for developing circular economy models around lithium batteries. The Moroccan government has been negotiating with electric vehicle battery manufacturers to set up a plant in the country and leverage its abundant critical minerals, including lithium and phosphates. Demand for such batteries is growing outside and within Morocco, where Citroen plans to double its production capacity within two years from 50,000 supermini electric cars. According to Eljechtimi (2022), Morocco is home to production plants of Renault and Stellantis with a combined production capacity of 700,000. Exports by some 250 Moroccan automotive manufacturers and part makers topped Morocco's industrial exports over the past seven years surpassing phosphate sales (Eljechtimi, 2022).

The Moroccan government has developed a vision for the automotive sector targeting 1 million cars production and full decarbonisation of manufacturing. This vision is aimed at attracting new players leveraging its local renewable energies, attractive logistic costs proximate to the

European market and highly skilled labour force. Engineering and R&D capacities have also grown in the country with the launch of the Africa Technical Centre for Stellantis, and the first Automobile Test Center in Africa which will allow Morocco to be autonomous in terms of validation and homologation of parts and vehicles. Recent investments also suggest Morocco has the potential to become the regional hub for EV manufacturing in the Middle East and North Africa (MENA) region. Morocco, currently, is the only country in MENA region that offers local supplies of EV battery metals through Managem. In July 2020 Managem announced its partnership with BMW to satisfy a fifth of its cobalt needs from 2020-2025.

Over the last two years, similar partnerships were reached with Renault, one of the two leading automakers in Morocco's autos industry alongside Stellantis. A further incentive for Renault is that the cobalt supplied by Morocco is expected to have a low carbon footprint, with up to 80% of the energy for production coming from renewable sources (OECD, 2023). The reduction in the carbon footprint of Morocco's cobalt supply will also be achieved through the recycling of end-of-life batteries. Opportunities for such circular economy model are presented in figure 10 below.

Figure 10: Circular economy of Lithium batteries



Source: Lombardo, 2020; first source: Argonne National Laboratory

On January 26, 2022, Managem also announced that it would construct another cobalt plant with partner Glencore near Marrakech, featuring an on-site cobalt recycling facility that aims to recycle cobalt, nickel and lithium, and also aim to produce cobalt from the black mass. The development of a circular economy model – end-to-end EV production – would potentially attract a string of complementary investments into the up, mid, and downstream sectors in Morocco's EV supply chain. Such investments would open the way for the development of a domestic EV vertical supply chain involving production of EV battery metals, batteries, EVs, and battery recycling. The co-location of these processes in the same country, Morocco, and the proximity to the European market, would make the country even more of an attractive location for EV manufacturing by providing local, reliable sources of all the parts and components to build EVs and, critically, recycling facilities to re-use costly EV battery metals in the production of EV batteries. By closing the loop in the supply chains, firms will be able to reuse the critical raw materials in EV batteries at a low cost, at a time when the prices of these commodities are projected to increase significantly.

4. Concluding remarks and policy direction

The transition to renewable energy sources and technologies is opening opportunities for developing countries to diversify into medium-and high- technology industries. Given Morocco's natural endowment in these energy sources, this paper explores the emerging opportunities and challenges for diversification into renewable energy technology value chains by Morocco. In doing so, the paper maps the renewable energy technology value chain and the sector-specific policies that have been implemented to analyse how Morocco is positioning itself to potentially localise and capture value within these supply networks, including leading the building and development of renewable energy technology regional value chains.

The paper shows that Morocco is well positioned, in terms of abundant critical mineral resource endowment and technological expertise, and can both leverage their current industrial capacity, skilled workforce, and growing experience in renewable energy to become regional leaders in solar panel manufacturing and assembly and industrial battery cell production.

More specifically, Morocco's diversification route in EV batteries can also leverage another important critical mineral abundant in the country, that is, phosphate (Tanchum, 2022). Globally, the EV battery industry is increasingly shifting towards replacing NMS Li-ion batteries with lithium iron phosphate batteries. While the latter do not provide the same long driving range performances, they can be much cheaper as they are not made with expensive cobalt and nickel as well as manganese. These critical minerals are replaced by relatively cheaper phosphate and iron. This further opportunity for diversification could finally link the development in the chemicals industry and the automotive industry, all backed up by a renewable energy sector. These inter-sectoral links point to the fact that diversification routes can in fact cross and reinforce each other in the overall process of structural transformation.

The Government, however, will have to closely develop and reinforce regional partnerships to create robust regional value chains. By locating domestic strategies as part of regional industrial development plans, Morocco could exert more bargaining power and realise greater cluster and scale economies. UNECA has identified several opportunities for regional value chains development cutting across Central Africa into East and Southern Africa for battery-minerals and electric-vehicles; a regional nitrogen, phosphorous and potassium 'super-fertilizer' value chain linking DRC, Ethiopia and Morocco and natural-gas-producing East, West, and Central African countries (Pedro, 2021). Exploring and leading these regional collaborations could position Morocco as a key regional player and drive the country's sustainable industrial growth and development.

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