Chapter 6

Phosphate mining and the circular economy: Morocco's OCP Group's approach to sustainable water use

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6.1 INTRODUCTION

Phosphorus is a unique mineral – an element of nature (P) and a product for which there is no substitute. It is fundamental to all living things, including humans, animals and plants, where it plays an important role in the germination, growth and development of crops and is a critical element in agriculture. In fact, the stability of the world's food supply has been linked to the continued availability of phosphorus to farmers everywhere. Morocco is home to 70% of the world's phosphate reserves, which have been mined, processed and marketed by the OCP Group (OCP) for a century. As custodian of this incredible natural resource, OCP is committed to the principles of a regenerative economy, including water conservation, recycling and reuse before, during and after extraction.

In 2008, OCP set out a major 20-year industrial development program to double mining operations and triple processing capacity in order to meet the growing global demand for food, while reducing the freshwater resources' part in its specific water consumption. Now, OCP's ambition is to go 100% non-conventional water resources by 2030.

This chapter describes how OCP increased its phosphorus production, bolstering Morocco's economy while reducing its impact on the environment and making significant social contributions at home and abroad. This transformation was accomplished through a deliberate culture change within the organization, and collaboration with partners and stakeholders within and outside the company. In water

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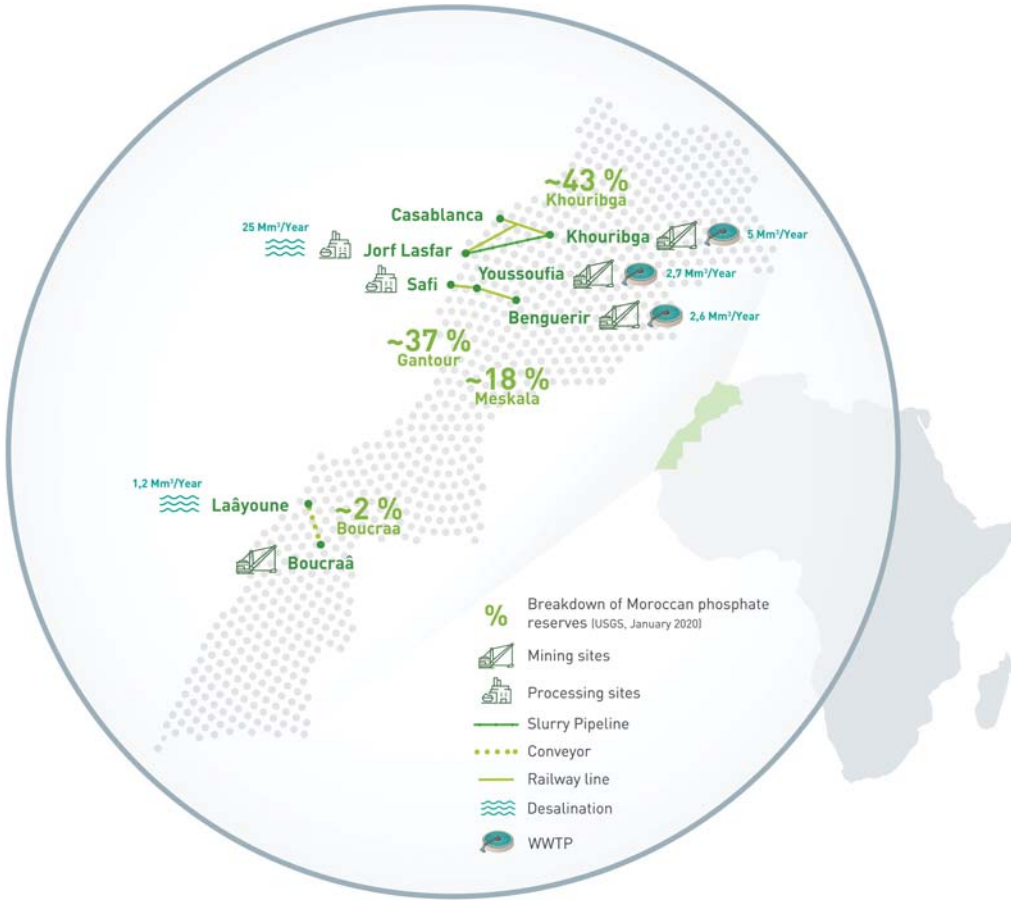

Figure 6.1 OCP's water treatment units in Morocco. (*Credit. OCP*).

stewardship, OCP's main achievements to date include (1) saving water and energy by bringing phosphate rock from inland mines to coastal processing facilities through a 235 km (146 mile) slurry pipeline; (2) desalinating seawater using self-produced clean energy to respond to its further need for water for phosphate processing and (3) reusing industrial wastewater and recycling municipal effluents within its mining areas (Figure 6.1). In addition, OCP has worked with farmers around the world, promoting water-saving techniques and customizing fertilizer products to meet local needs and maximize the benefits of phosphorus in agriculture.

6.2 PATHWAY TO A CIRCULAR ECONOMY

Founded in 1920, OCP plays an important role in feeding a growing global population, by providing essential elements for soil fertility and plant growth. It covers the entire phosphate value chain, from mining to processing. The company produces phosphate rock, phosphoric acid and a wide range of customized fertilizers, the bulk of which are exported worldwide. OCP's activities are concentrated in

three regions in Morocco: the mines of Khouribga and the processing hub and port of Jorf Lasfar in central Morocco; the mines of Gantour and the processing hub and port of Safi, and in central Morocco; and the mines of Boucraâ with the port of Laayoune in Morocco's southern region (Figure 6.1). OCP is the Kingdom's largest company generating nearly 6% of the country's GDP (Trading Economics, 2020) employing around 21,000 people and supporting an additional 40,000 indirect jobs in Morocco, across Africa and around the world.

As a major contributor to the global fertilizer market, OCP supports the transition towards a more prosperous, sustainable and resilient agriculture. The Group is implementing a strategy that strengthens its status as one of the most sustainable fertilizer producers in the world and thus contributes to achieving the UN Sustainable Development Goals (SDGs).

According to the Global Footprint Network, people are consuming nature's resources 1.7 times faster than our planet's ecosystems can regenerate them (UNFCC, 2018). If nothing changes, this rate may double as a result of population and economic growth. The issue then is to meet growing consumption needs while preserving resources as much as possible, a major challenge that the world must take up today, especially industrial companies. OCP has responded to this challenge by creating the 'Circular Economy program' in the phosphate and fertilizer industry. The objective was to take OCP's long-standing commitment to the environment and sustainability one step further. As stated by Chairman and Chief Executive Officer Mostafa Terrab, in OCP's 2018 Sustainability Report, 'the challenge is to feed a growing world population while using resources responsibly and continually striving to reduce its environmental footprint' (OCP, 2018).

6.2.1 Transitioning from Linear to cyclic production

In 2018, OCP set ambitious goals by launching the 'Circular Economy program' whose aim is to create a green dynamic, as well as to foster symbiosis with the industrial ecosystem and communities.

This new approach consists of moving from a linear pattern of resource consumption to a circular model, optimizing products from their design to their end of life, including their production, use and reuse. It is implemented through four components: preservation of resources, sustainable production, smart consumption and valorization of waste into resource (Figure 6.2). The 'Circular Economy program' contributes to better value creation for the Group's customers and partners; it also benefits its employees and the people living on its sites.

OCP's focus on the circular economy is demonstrated, in part, by its implementation of technologies that reduce pollution. For instance, air control technologies have reduced emissions of SO_2 in sulfuric acid production by up to 98% (ten times lower than the World Bank threshold), while 86% of the power used by the Group comes from clean energy, with an objective of self-sufficiency by 2030. In 2019, more than 30% of OCP's water needs were met through non-conventional water resources and the firm's new ambition is to reach 100% by 2030 thanks to its water program.

6.2.2 Creating a movement

OCP's ability to implement the 'Circular Economy program' has been based on an organizational culture and agile management that actively supports creativity, collaboration and innovation. This ambitious program is the result, like so many others within the company, of an original program called the 'Movement.' Launched in 2016, it allows any OCP employee to develop a project to address the challenges faced and to be backed with the proper resources to implement their idea. The Movement's goal is to 'positively disrupt the company' by allowing the 9000 employees involved in the program today to make proposals through a non-hierarchical process and according to their own areas of interest.

Figure 6.2 OCP's Circular Economy framework. (*Credit. OCP*).

OCP also invests heavily in professional development and encourages employees to volunteer in their surrounding communities through its 'Act4community program', designed to boost citizenship initiatives. In 2019, 3307 OCP employees volunteered almost 11,110 hours to various associations and communities (OCP, 2019) (Figure 6.3).

The company's support for building expertise and supporting innovation extends beyond its own employees. OCP's support for education and skills training is reflected in all layers of its business ecosystem. In 2012, OCP developed the Mohammed VI Polytechnic University (UM6P), which aims to offer cutting-edge world-class education in applied research and development in science and technology, providing the tools and skills for future generations of African leaders. Besides, the company provides skills training to its suppliers through four Industrial Expertise Centers. In 2018, OCP provided training on improved agricultural practices in seven African countries outside Morocco, as well as 10,000 farmers in India. The Group collaborates also with NGOs and civil society to promote business skills, job creation and access to education, health and culture.

6.3 WATER FROM THE ROCK

OCP's $20 billion 20-year capital investment program to increase its industrial capacity began with a full engineering review of the phosphate value chain: mining, phosphoric acid processing and production of finished fertilizers. Knowing that the use of water occurs at each stage of its value chain (mining, transport and transformation), the company invested heavily in a system that integrated the reuse and sustainable preservation of water throughout its entire production process, starting with extraction.

Figure 6.3 OCP human capital in one of Khouribga's phosphate washing plants. (*Credit. OCP*).

Phosphate mining involves spraying water for dust control along mining trucks' roads. Once extracted, the phosphorus-bearing rock is washed in the beneficiation plants, which recycle 80% of the used water (Figure 6.3). Then, the washed phosphate is either dried for transport by train (from Benguerir and Youssoufia in the Gantour basin to Safi) or sent as a pulp down a slurry pipeline (from Khouribga to Jorf Lasfar) for processing. Once in the processing units and depending on their requirements, more water is added to the pulp from the slurry pipeline or to the dried phosphate that has been transported by train to produce either phosphoric acid or fertilizers (Figure 6.4).

OCP's challenge was to meet its growing mining and industrial water needs – which will rise from 63 million cubic meters (46 mgd) in 2010 to 180 million cubic meters per year (130 mgd) by 2030 – without either withdrawing more water from nearby dams or tapping underground aquifers and draining the Kingdom's strategic water reserves.

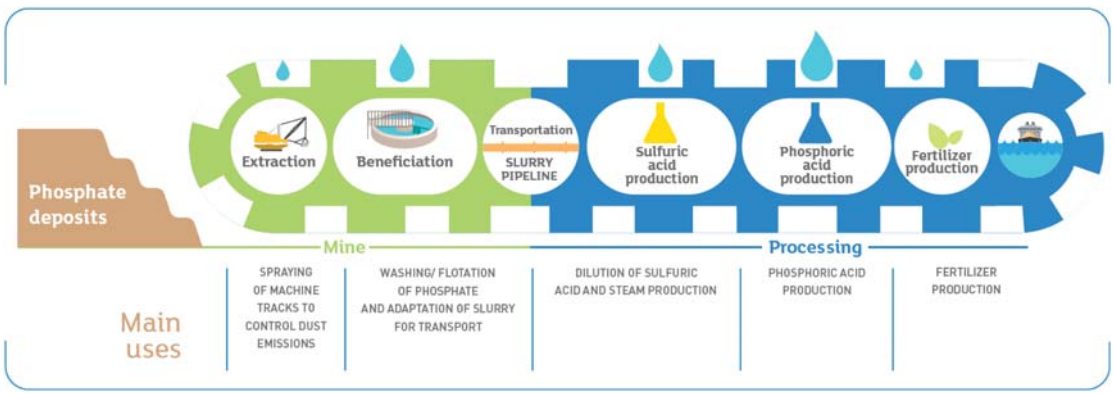

Figure 6.4 Water chain configuration for slurry pipeline transportation mode. (*Credit. OCP*).

Figure 6.5 Slurry Pipeline's terminal station in Jorf Lasfar. (*Credit. OCP*).

Facing the increasing global demand for fertilizers and Morocco's increasing water scarcity, OCP started by asking its engineers and scientists to reconsider water use in every aspect of its production in terms of what would minimize impact on the environment and what would most benefit its multiple stakeholders. Taking into consideration the National Water Strategy, their analysis produced a dedicated integrated water program based on circular economy principles. In response, the company launched many projects to optimize water use across the entire value chain. OCP decided to stop relying on groundwater and to reduce surface water use while promoting use of non-conventional water resources: treated (domestic) wastewater and desalinated seawater.

For instance, OCP realized an annual saving of nearly 3 million cubic meters of water per year (2 mgd) by constructing the world's largest phosphate slurry pipeline to transport phosphate rock from the mine to the processing facility (Figure 6.5). This mode of hydraulic transport eliminated the drying step, which was necessary for rail transport, making it possible to retain the natural humidity of phosphate rock which can be recovered and reused at the processing facility. OCP invested $500 million in a 235 km (146 mile) underground pipeline to transport phosphate rock from the Khouribga mines to the Jorf Lasfar processing facility. Commissioned in 2014, the pipeline has a total capacity of 38 million tons of phosphate per year. In addition to transporting higher volumes than previously possible via rail, the pipeline enables significant reductions in logistics costs and carbon emissions (reduction of 930,000 metric tons of CO_2 emissions per year). The process of transporting slurry from Khouribga to Jorf Lasfar takes 24 hours and is gravity-powered, requiring almost zero energy.

6.4 CIRCULAR DESALINATION

Once the phosphate slurry arrives at the processing hub, additional water is needed to produce phosphate-based products. To supply this water, OCP has invested in seawater reverse osmosis (SWRO) desalination facilities, including the Jorf Lasfar unit, the largest desalination plant in Morocco, supplying up to 25 MCM per year (18 mgd) with plans to expand by 2022 to 40 MCM per year (29 mgd). This

Figure 6.6 Ultrafiltration unit of OCP's desalination plant in Jorf Lasfar. (*Credit. OCP*).

follows the SWRO plant built in 2006 at Laayoune site with a capacity of 1.2 MCM. As an example of the circular economy, the Jorf Lasfar unit (Figure 6.6) runs on surplus clean energy created by the phosphate manufacturing process, where the generation of steam to produce sulfuric acid is transformed into electrical energy.

Taking into account the constraints of seawater quality variation on the costal intake, the plant has been designed with an advanced pretreatment unit (Dissolved Air Flotation + Ultrafiltration) to insure a high pretreated water quality and maximum availability. OCP has also adopted the best-in-place energy recovery device's technology, to produce the desalinated water with the most efficient manner at that time. The water then is re-mineralized and sent to water tanks in order to be distributed to the different consumers. In addition to the on-site effluent treatment, the brine generated by the plant (less than 3.5% of the overall water used by the platform) is diluted into the pumped cooling water and then reused in the hub's processing units.

Additional SWRO desalination plants are under study in several other areas to respond to OCP's industrial growth and the resulting increasing water demand. OCP is tracking the most innovative technologies that allow reductions to the cost of desalinated water, including renewable energy.

6.5 FROM WASTE TO RESOURCE

In addition to seawater desalination plants, OCP has also invested in urban wastewater recycling facilities (wastewater treatment plant; WWTP). In fact, OCP has helped several municipalities treat their domestic effluent, to preserve the environment as well as the national freshwater resources. This service helps protect communities and the environment while producing highly treated wastewater that can be used in OCP's production facilities.

Over the last decade, OCP has developed municipal treatment plants in the mining cities of Khouribga, Benguerir and Youssoufia in order to recover and reuse over 10 million cubic meters per year (7 mgd) of urban wastewater (Figure 6.7). These plants have been designed to treat the wastewater with

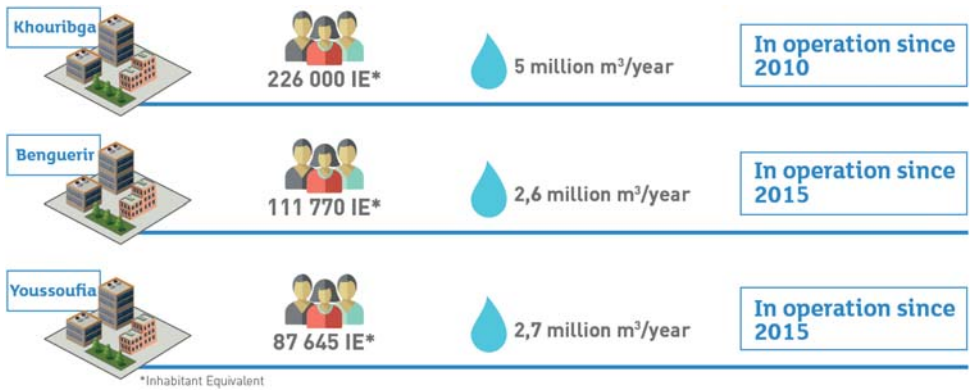

Figure 6.7 The wastewater treatment plants built in OCP's mining cities. (*Credit. OCP*).

cutting-edge techniques, providing excellent overall performance (activated sludge technology). Khouribga's WWTP, the largest plant, has been in operation since 2010 and enabled the first experience worldwide of reusing treated wastewater in phosphate mining.

Benguerir is located in the central region of Morocco, between Casablanca and Marrakesh, and is home to the recently built Mohammed VI Polytechnic University (UM6P). The region suffers from a scarcity of water resources, and is a good example of collaboration between OCP and the municipality, where the WWTP generates about 2.6 million cubic meters per year (2 mgd) of treated domestic wastewater (Figure 6.8).

Figure 6.8 Benguerir's wastewater treatment plant. (*Credit. OCP*).

The human waste initially travels from homes to a pumping station, 4 km outside of Benguerir, where it is pumped to the WWTP. There it undergoes pretreatment, including screening and a process to remove oils and sand followed by primary sedimentation. The secondary treatment process begins in a biological tank that provides an environment that encourages bacteria to grow with a sufficient and controlled supply of oxygen that varies with the quality of the wastewater received. This is followed by tertiary treatment, a three-stage process: (1) microfiltration, which eliminates residual dirt and suspended solids in the water; (2) granular activated carbon filtration, which removes many organics and produces a high quality effluent; and (3) disinfection with hypochlorite, which kills bacteria, viruses and other potential pathogens. After treatment, the majority of water from the plant is sent to the Benguerir mine where it is used primarily for dust control on mining roads. It is also used to water the green spaces in the Mohammed VI Green City of Benguerir. The remaining water is piped to Youssoufia 60 km (36 miles) away, where it is used in place of groundwater to wash phosphate.

The sludge generated by the wastewater treatment is sent to the thickeners and the digester where it produces biogas. The recovery of biogas emitted during the wastewater treatment process covers more than 30% of the electrical and thermal energy needed to operate the WWTP. After that, the stabilized sludge is dewatered by centrifuge machines and allowed to dry to 70% solids in solar drying units. Reuse of sludge in the mining areas is currently being tested.

Still in accordance with the circular economy vision, the industrial reuse of treated wastewater from other existing or new WWTP is being studied.

6.6 LOOKING TO THE FUTURE

As an essential input for its industrial processes, OCP recognizes, respects and values Morocco's most precious natural resource: water.

Over the past decade, the water program implemented by OCP has enabled the company to sustainably ramp up production and ensure food security while preserving national freshwater resources. 'Thinking

Figure 6.9 OCP agronomist supporting a Moroccan farmer (Credit: OCP).

outside the reservoir' has led OCP to identify every possible drop of water to be saved throughout its value chain and to make the voluntary decision to shift from conventional to non-conventional water resources, even at a higher cost (Figure 6.9). OCP's initiative has attracted international attention as a model of corporate sustainable water use and financial institutions, including the French Development Agency (AFD) and the German development fund (KFW), have granted OCP a $500 million USD loan to implement the first wave of its water program. In addition to its technical innovations, OCP's continuous improvement efforts show how a state-owned company's commitment to sustainability can achieve environmental and social objectives that support domestic and foreign policies.

The adventure is not over. The company has set even more ambitious goals and is constantly looking for new ideas, cutting-edge tools and revolutionary models to improve its performance and increase its innovation capacities. This would not be possible without collaboration with the other stakeholders of its business ecosystem, increasing joint-ventures in different fields and inclusive partnerships with world-class companies and universities and working hand-in-hand with authorities and civil society to create a more sustainable future for business, the community and the environment.

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