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How mini refineries create business opportunities in developing economies

Research Objectives

Dr Singh reviews the current status of modular-mini refineries as business opportunities in developing economies.

Detail

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Bio

Dr Himmat Singh served as Scientist 'G' at the CSIR-Indian Institute of Petroleum, Dehradun, in the area of Petroleum Refining. Post retirement, he served as Advisor R&D with BPCL, Mumbai. Total applied research experience 39 years. Also served for 15+ years as Professor and Head of Department at three Indian universities. Dr Singh holds an MSc in Chemistry, Diplome D'Ingenieur in Rafinage et Petrochemie from ENSPM of IFP France, and a Doctorate in Refining of Lube Base Stocks. He has published 200+ papers, 64 in foreign journals. Recipient of many prestigious awards. Currently a consultant.

References

Singh, Himmat (2021) Modular-mini refineries: Business opportunities in developing economies. *African Journal of Science, Technology, Innovation and Development*. doi.org/10.1080/20421338.2021.1923124

Personal Response

How popular do you think mini refineries will become?

// There have been some government initiatives (Nigeria, Indonesia, etc) that aim to add local refining capacity to offset continued import growth of finished products for increasing consumer demand. The goal is to provide a steady supply of fuels and products at lower cost on a local level. This approach also consumes oil obtained in-country, benefitting from lower regional pricing, transportation, and other incentives such as local jobs creation. Additional advantages include lower investment costs, adjusting for lower local demand, shorter schedule, and possibility for future relocation. The above considerations will continue to make mini refineries popular in developing countries. //

How mini refineries create business opportunities in developing economies

Petroleum refineries are a huge source of transportation fuels, lubricants, and the starting blocks for chemical synthesis. Even as alternative renewable sources for energy start to replace some demand for petroleum, it is unlikely our dependence on petroleum products and petroleum as a chemical feedstock will be broken any time soon. Dr Himmat Singh, former Chief Scientist at the CSIR-Indian Institute of Petroleum, has been investigating how developing economies can exploit modular-mini refineries for petroleum refining and product manufacture.

Petroleum starts its life as crude oil: a black, tarry mess of chemical compounds that is of limited use in its natural state. The real value of crude oil comes from what can be made from it. Turning crude oil into valuable petroleum gases, transportation fuels like gasoline and diesel, lubricant base stocks, bitumen etc involves a process called petroleum refining.

Petroleum refining consists of several chemical engineering processes designed to separate the different chemical fractions / products from each other. One of the most common ways of doing this is through a process called fractional distillation. The crude oil – primarily a mixture of hydrocarbons – is placed in a column and the temperature is raised until the mixture starts to boil. As the liquid starts boiling, vapours are formed and the column is held at a temperature gradient, with the lowest temperature at the top and the highest temperature at the bottom.

As crude oil is a mixture of many different chemical species, each of these has their own boiling point and, therefore, will start to form vapour at different temperatures. The smallest and lightest chemical species tend to have the lowest boiling points. They begin to form vapour first and reach the top of the column. When the gaseous species arrive at regions with temperatures lower than their boiling points, they start to condense and form liquid. This liquid run-off can then be collected and either further processed or used as is.

Petroleum refineries have typically been large pieces of infrastructure, in parts because of the huge demand for oil refining and the costly infrastructure involved in the creation of the fractional distillation columns and further refinement steps. Costs associated with oil refining continue to increase as there have been moves towards legislating fuel composition more heavily, including needing reduced sulfur levels in diesel

Crude oil can be turned into valuable products such as gasoline and diesel. This involves a process called petroleum refining.

and higher octane levels in gasoline in road transport fuels.

Crude oil prices have often suffered with great volatility, from stresses on demand to issues with supply due to factors such as accidents involving fires and damages to refineries. This has, in turn, put pressure on the ability of oil refineries to be economically viable or generate profit. Due to the expenses associated with maintaining plant equipment, large refineries are often dependent on subsidies to continue performing a job that is critical to the functioning of a nation. However, in the face of market price volatility, what happens in countries that cannot necessarily afford to build and maintain such large, but essential, infrastructure and have a rich crude oil source of their own?

Dr Himmat Singh, who has worked as a chief scientist, technical advisor, and consultant in many roles across the petroleum industry, has been investigating how mini refineries may offer a reliable and affordable route to securing petroleum product manufacture in developing economies.

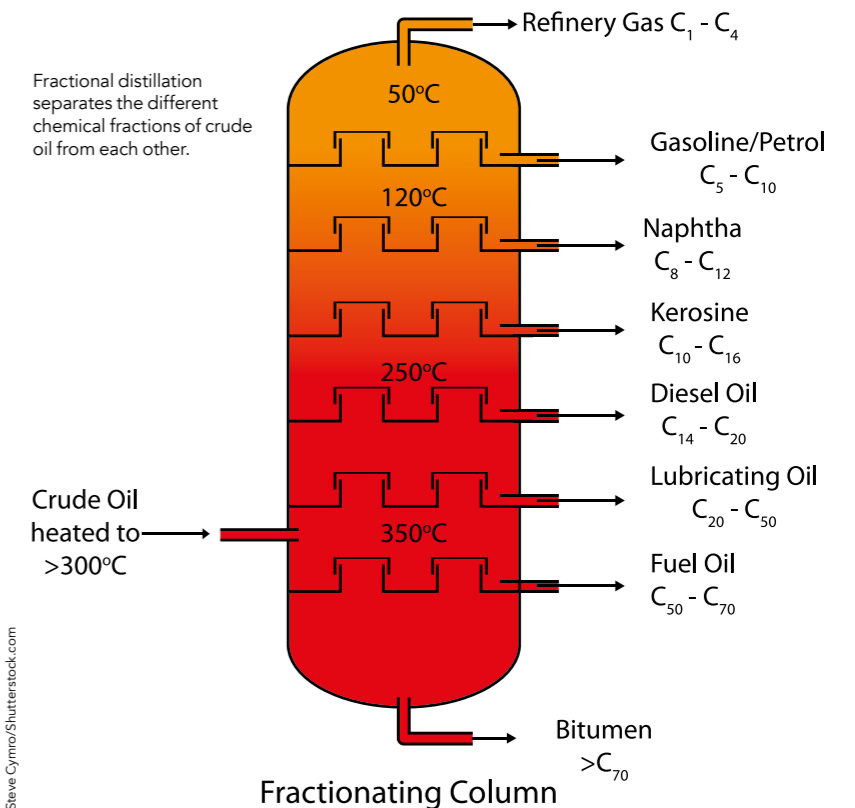
MINI REFINERIES

Mini refineries are scaled-down versions of standard oil refineries. While they produce fewer barrels of refined products each day, they are also less cost intensive and can be used more flexibly to respond to increases and falls in demand, without the inefficiencies of larger plants. Mini refineries are highly appealing in oil-rich countries, such

as Nigeria, where there are significant oil reserves but refined products are imported to meet national needs, which further stresses the economical returns from petroleum resources.

A mini refinery is defined as a refinery that produces less than 5,000 barrels of oil a day – however, this is a loosely agreed-upon definition. Mini refinery designs can vary, particularly if they are

Another part of the mini refineries' appeal comes from their greater environmental friendliness compared to more traditional plant designs.





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of a modular construction. Modular-mini refineries are intended to be easy-to-construct refineries that can be customised for consumer demands.

Dr Singh notes that much of the interest around modular-mini refineries is 'viable for investment from both public and private sector groups' and their appeal comes from how quickly they can be set up and begin production of primary fuel products and raw materials for further processing. Another benefit comes from their greater environmental friendliness compared to more traditional plant designs. The scale of smaller refineries means that they pose a much smaller environmental risk in the event of an accident. Moreover, there is likely to be much less wasted capacity in the event of a fall in demand compared to larger petroleum refinement infrastructure.

Demand for such installations is growing. A single design company



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Modular oil treatment units are easy to construct.

was working on more than 18 proposals across the Middle East and Africa. Other countries, with larger amounts of large petroleum-refining infrastructure, such as the US and Indonesia, are also starting to invest in modular-mini refineries to monetise their assets. Drastic drops in the price of crude oil have made the expenses of running larger plants unappealing, and mini refineries can offer a cost-effective alternative in times of lower demand.

NIGERIAN REFINERIES

One area where modular-mini refineries have proved a huge success is Nigeria. In a hope to reduce the country's dependence on externally refined products, the Nigerian government and other investors pushed the development of modular-mini refineries across the state. This was in part due to many larger-scale operations being inconsistent and facing disruptions with possibly poor-quality products, and also due to a desire to reduce refinement

costs to extract the maximum value from the country's large crude oil reserves.

Dr Singh reports on the huge success of the Ogbele Plant. Sitting at just 204 m of total footprint, the refinery can deliver high-grade diesel and has suffered 0% losses. 89% of the diesel produced here is sold to the home market, to quench the 1 billion litres a year demand for diesel in Nigeria. The success of the plant has inspired expansion to both produce a large number of barrels per day but also to extend the range of products that can be produced and refined there. The project was the first marginal field to be awarded to an indigenous company, the Niger Delta Exploration & Production Plc (NDEP).

Now NDEP is producing over 19 million barrels of crude oil and over 90 billion standard cubic feet (Bscf) of gas. It has evolved into an integrated energy company looking for further opportunities to enhance Nigeria's oil and gas chain. This includes looking at similar projects in South Sudan. The success and work done at Ogbele, performed by just two technicians working in 12-hour shifts, may be instrumental in seeing Nigeria recognised as a major exporter of petroleum products, providing both a secure and stable internal supply and

a valuable financial opportunity. It also translates into the creation of jobs and training opportunities.

A former Chairman of the Board of Directors of the Company, Ogbueshi Ben Osuno, recalled some of the key challenges NDEP faced at the inception of operations. He said NDEP 'is seen as a major accomplishment because we have grown from being a single well company into a crude oil and gas producing, processing, refining and exporting company.'

INDONESIAN REFINERIES

Indonesian mini refineries are a key part of the country's strategy to double oil output by 2025. There is growing national demand and problems

meet demand and to avoid devaluing their own products. At present, most of the extracts are intended for the domestic market, but there is particular interest in producing high-quality, low-sulfur content fuels. Currently, there are 10 mini refineries in various stage of development being supported by a number of international investors.

LOOKING AHEAD

Modular-mini refineries offer a flexible way of providing crude oil refinement capabilities without the same levels of initial outlay required as large refinement plants. The modular design allows acceleration of the construction of the refinery and, if current efforts to find ways to scale down the size of components and structures prove successful, modular-mini refineries may soon be easier to transport and assemble.

The ability to have local refineries even in remote locations will help to reduce costs associated

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with aging local facilities that mean production levels are falling. Mini refineries offer a quick route to high-value products and can help meet the need for increase capacity quickly.

For Indonesia, another advantage of moving towards a mini refinery route is that this gives suppliers the flexibility to scale up or scale down production to

with transportation and, crucially, ensure regions are not as vulnerable to fluctuations in market prices and external exports. Many companies are already manufacturing a range of mini refinery designs and they may offer a route to better security in local feedstock and fuel supplies. They are also likely to drive greater infrastructure developments in high oil and gas demand regions – developments and investment which will in turn provide resources for the low-carbon transitions.



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The Nigerian government pushed the development of modular-mini refineries to extract the maximum value of the country's crude oil resources.

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