

Update on Oxygen Delivery Systems: June 2021

Oxygen is a critical resource needed to treat covid. While oxygen is always needed in hospitals, covid is severely straining existing supply of oxygen. Medical oxygen is delivered in three main forms:

- Oxygen Concentrators: Devices meant for one patient supplying up to 10LPM by generating medical grade oxygen from room air
- PSA/VSA plants: Independent plant that generates oxygen to be supplied by cylinder or piped systems to hospitals and clinics
- Cryogenic Oxygen: Industrial plants producing high volumes of very pure liquid oxygen to supply many industries

Oxygen Delivery	Benefits	Drawbacks	Installation Timeline
Oxygen Concentrators	<ol style="list-style-type: none"> 1. Produce 90%+ purity oxygen 2. Can easily increase oxygen capacity by adding more concentrators 3. Easily shipped to rural areas 4. Easily used in field hospitals/covid treatment centers as no cylinders or piped systems are required 5. Simple maintenance required for long term use 6. Safe for home/patient use 	<ol style="list-style-type: none"> 1. Each concentrator only produces enough oxygen for one patient typically up to 10LPM 2. Requires electricity/power source to operate 3. Low quality machines are abundant with low purity at higher flow settings 4. General lifetime per device is 3-5 years 	Immediate
PSA/VSA plants	<ol style="list-style-type: none"> 1. Can be installed within a hospital for direct connection through piped systems 2. Medical grade oxygen 3. Typically, 200 (in hospital)-1,500 LPM production 4. Long term production capability: 15-20 years 	<ol style="list-style-type: none"> 1. Require a lot of maintenance 2. Need cylinders and filling stations for deployment from central plant to other clinics 3. Can only produce a fixed amount of oxygen 4. Medium investment 5. Strict safety protocols to follow 6. Requires electricity/power source to operate 	4-8 months
Cryogenic or Liquid Oxygen Plants	<ol style="list-style-type: none"> 1. Highest purity oxygen (99%+) 2. High volume production 2,000,000 LPH 3. Applications in many industries like mining, industrial use, etc. 4. Long term production capability: 30-50 years 	<ol style="list-style-type: none"> 1. Need robust infrastructure with strong roads and specific trucks for liquid oxygen 2. Strict safety protocols to follow 3. ISO tanks required at hospitals 4. Sophisticated technology requiring trained technicians 5. Very high investment 	2 years +

The different systems must work together to meet the oxygen needs of a country during covid and after. Oxygen concentrators can be provided very quickly and deployed to remote clinics, temporary clinics, and hospitals. PSA/VSA plants take time to install and are more expensive. They require continual maintenance. Cryogenic plants require the most time to install and are the most expensive. Both PSA/VSA and cryogenic plants require a robust and sophisticated infrastructure to send the oxygen from the plant to a hospital or clinic that is set up to receive it. This involves careful forecasting and as such, these systems are not easy to scale up or down quickly.

Sanrai is one of the largest suppliers of oxygen concentrators across the emerging markets. We have relationships with several manufacturers of concentrators. Due to the realities of covid, there has been a strain on the production of oxygen concentrators for 15 months now. The constraints in supply are expected to continue for at least 6 months, likely for at least another year. As more countries experience an increase in covid cases, more concentrators are being required. There are significant shortages in the components needed to produce concentrators.

Oxygen concentrators can range in liters per minute, but the most common units are either 5 LPM or 10LPM. 10 LPM units are about 10-20% of the global production. As such, there is a significant shortage comparatively in 10 LPM devices versus 5 LPM units. The higher flows are needed to treat more critical patients. There is a well understood system to link two 5 LPM concentrators of high quality together to produce a true 10 LPM flow for one patient. Some field hospitals have linked several concentrators together to produce enough oxygen for many patients through a piped system. It is essential to use concentrators that comply with international standards and produce oxygen above 90% at all flow levels.

Oxygen concentrators have to be a part of the solution to provide oxygen across the emerging markets. Concentrators give decision makers the ability to easily provide oxygen where it's needed as the devices can be moved around quite quickly within a hospital system or within a country. PSA/VSA or cryogenic plants are limited in where they can provide oxygen. They are good for larger hospitals and metro areas, but given the infrastructure challenges, they will never be able to provide oxygen to the majority of centers requiring oxygen. To truly upgrade a country's oxygen infrastructure, it will take years.

Countries without high vaccination rates will continue to see waves of covid as they cannot afford to be in lockdown until a significant percentage of the population is vaccinated. The time to increase the amount of available oxygen in country is now.