CASE STUDY

PATH

Strengthening peripheral systems to PSA oxygen plant

A case of Sadar Hospital, Samastipur, Bihar, India

Samastipur is a district located on the banks of Budhi Gandak River in Darbhanga Division of Bihar. The district has a 100-bedded Sadar Hospital, which is one of the largest public health facilities in the division. For a population of more than 4.26 million, there are only four subdivisional hospitals, 20 primary health centers, 52 additional primary health centers, and 360 health subcenters in Samastipur district, besides the Sadar Hospital. These facilities, which do not have critical care units, directly refer the severe cases to the Sadar Hospital.

During the COVID-19 pandemic, the district recorded a high positivity rate, topping more than 600 new cases per day, which at one time was second only to the state capital of Patna in Bihar. The Sadar Hospital, which is located at the heart of Samastipur city, acted as a referral unit due to the limited availability of oxygen. It managed the moderate cases of COVID-19 by advising patients for home isolation and admitting only the critically ill patients to the hospital for case management. However, due to limited oxygen, it referred most of the severe cases to either the Darbhanga Medical College and Hospital or the Sri Krishna Medical College and Hospital in Muzaffarpur for treatment, which is approximately 3,040 kilometers away from it.

Strengthening oxygen systems in the Sadar Hospital, Samastipur

The Sadar Hospital had traditionally relied on oxygen cylinders as the primary source of oxygen, which were refilled and supplied by private vendors under contract to the hospital. During the second wave of the pandemic, the Sadar Hospital experienced disruption in the oxygen supply as the state government experienced several challenges in procuring a daily supply of around 274 metric tons (MT) of liquid oxygen needed to meet the unprecedented surge in the demand for medical oxygen.

Realizing that the supply of oxygen through cylinders cannot be relied on as the primary source of medical oxygen to meet future surges in oxygen demand in public health facilities, the Government of Bihar prioritized building reliable oxygen systems across all public sector tertiary care facilities in the state. Furthermore, the government collaborated with various development partners to sustainably improve the production and delivery of medical oxygen in the state.

In an effort to support the government in strengthening the oxygen ecosystem, PATH, in partnership with Bill & Melinda Gates Foundation, provided technical support to the state government for setting up pressure swing adsorption (PSA) oxygen plants and conducting mock drills to ensure the functionality and achievement of the required pressure flow and oxygen purity of all the PSA plants. The state government selected the Sadar Hospital as one of the five sites for installing the PSA plant procured with the support of Bill & Melinda Gates Foundation.

The journey from site allocation at the Sadar Hospital for the PSA plant to the time it was commissioned had several challenges. This case study is an insight into how PATH, working with various stakeholders at the state, district, and facility levels, responded to those challenges, and the lessons that it offers for similar initiatives in the country and globally.

Suboptimal oxygen infrastructure for supporting the PSA plant

When PATH's technical team visited the Sadar Hospital for a preinstallation evaluation, it assessed that the hospital required a PSA plant of around 1,000 liters per minute (LPM) capacity, but the compactly built facility did not have enough open space within its premises to establish an oxygen generation plant of this size and capacity. Furthermore, the facility had five manifold rooms, with each room equipped with only two cylinders arranged arbitrarily and not meeting the structural design requirements of a manifold room. As a result, the hospital was not able to effectively supply oxygen to all the patients requiring oxygen therapy. The five manifold rooms at different locations of the hospital were also occupying vital space, which could be used for expanding and strengthening the oxygen infrastructure in the hospital.

A team of biomedical engineers from PATH alerted the hospital authorities about the need to dismantle all the five smaller manifold rooms. The team explained that the manifold room should have the capacity of at least four cylinders and a copper pipe of at least 2-inch diameter to deliver oxygen at the desired volume and

Figure 1: One of the five old manifolds at Sadar Hospital for two oxygen cylinders

Figure 2: Construction of a central manifold room at Sadar Hospital

Figure 3: The new central manifold room at Sadar Hospital for eight cylinders

a flow of 4.2–5.5 bar to all oxygen beds and ICU beds in the facility. PATH also provided the hospital authorities with a site location and design for a central manifold room with a medical gas pipeline system (MGPS), which suits the requirement for a 1,000 LPM PSA plant.

The technical advisory was understood and accepted by the hospital officials, and the design, location of the central manifold room, and installation of MGPS were approved. PATH provided technical support to the civil engineering consultants for constructing the central manifold room. Owing to the combined efforts of the PATH team and the hospital administration, the facility now houses a central manifold room with a capacity of eight cylinders that caters to 107 beds supported by a gas pipeline.

Potential oxygen hazard risk at the PSA plant site

During another visit to review the site identified for the PSA plant, the team of biomedical engineers from PATH realized that an electrical power transformer was located within close proximity of 5 meters from the allocated PSA site. This spacing between the proposed PSA plant and the transformer was not within the recommended distance as it increases the risk of accidental fire due to potential leakage of oxygen.

The technical team shared its findings with both district health officials and hospital authorities and recommended following international standards for MGPS to prevent any kind of damage. Furthermore, as the hospital is located in a compact campus and as the already identified site was the only adequate space for the plant, the hospital authorities and the civil surgeon agreed to request the Electrical Department to relocate the power transformer. However, as stated by the electrical engineer, the shifting of the transformer would lead to a few challenges such as 7-8 hours of load shedding, hampering business and potentially causing a law-and-order situation. PATH further escalated the issue of the proximity of the transformer to the PSA plant site with the Additional Chief Secretary, Health Department, Government of Bihar, at the state level. The Additional Chief Secretary, in turn, brought the concern to the notice of the Superintendent Electrical Engineer of the North Bihar Power Distribution Company Limited (NBPDCL), and the issue was resolved.

Reflecting on the long-drawn process of getting the power transformer shifted, Parimal Chandra, State Lead, Respiratory Care Management in PATH, observed,

“It took several follow-ups with the Electricity Department at state as well as the district levels. Our persistence finally paid off and the transformer was shifted away from its location to a new place, which was at least half a kilometer away from the PSA plant site.”

With the power transformer shifted, PATH began preparing the site for the PSA plant. PATH not only did the civil work, constructed the roof and shade of the building, and installed the PSA plant, but also coordinated with the Electrical Department and the Bihar Medical Services and Infrastructure Corporation Ltd. (BMSICL) to get the electricity connection from the transformer to the electrical panel and installation of the MGPS, respectively.

Despite best efforts to prepare the site, the installation of the PSA plant was delayed. Heavy rains during the monsoons hampered the construction work, and there were significant delays in the delivery of components and subparts of the PSA plant and their assembly at the site by the vendor.

Exposed electrical cables

On December 23, 2021, as in other parts of the country, the Bihar government also launched dry runs and mock drills of all statewide PSA plants. Initially, the PSA plant at Sadar Hospital functioned normally, but after 3–4 hours of working, the plant stopped abruptly. The issue was reported by the civil surgeon of the hospital to the Additional Chief Secretary in a virtual meeting where PATH representatives were also present as part of the State’s Technical Assistance

Unit. Following this, the PATH team visited the PSA site at the hospital and found that about 15 meters of the electrical cable attached to the plant was destroyed due to fire. The team deduced that the cause of the fire was a short circuit, which might have been caused for various reasons, such as rainwater getting around the cables, high heat generation, or loose connections between cables.

Figure 4: The electrical cable that got burnt at Sadar Hospital due to a short circuit caused by rainwater

Since the PSA plant was partially handed over to the hospital authorities, PATH had to facilitate a discussion with BMSICL in order to replace the cable. After a series of meetings with the officials and internal approvals, BMSICL replaced the electrical cables. Sadar Hospital's PSA plant is fully functional now and is serving patients who need oxygen support.

Lessons learned

- **It is important that peripheral systems to oxygen plants meet the minimum standards to improve the efficiency of oxygen systems.** As the case study shows, strengthening systems that store and carry oxygen, such as manifold rooms, and ensuring that the oxygen plant sites meet minimum site criteria, such as distance from transformers and medical gas pipelines, among others, help in delivering oxygen of the desired quality and flow rate. In this context, the case study shows the value of ensuring technical specifications of various components in an oxygen ecosystem. Any inferior quality product can increase the vulnerability of the systems and increase the risk to life.
- **There are many stakeholders in the installation of a PSA plant, and each one must play their role for the PSA plant to function efficiently.** As observed in the case study, the state and district health officials, the hospital authorities, the civil contractors, PATH, the Electrical Department, and BMSICL, in addition to the PSA plant vendor, were the key stakeholders. Delays and errors occurred when some of the stakeholders did not play their roles to their fullest capacity. It is important that all stakeholders know and understand their roles, as well as adhere to a minimum standard of performance, to achieve a common result.

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Date Published

April 2022