25 MAI 2021

REPUBLIC OF RWANDA

Kigali,
N°20/2709 /DCPHS/2021

MINISTRY OF HEALTH
P.O.BOX 84 KIGALI
www.moh.gov.rw

**Chief Executive Officer of Rwanda Development Board**
**KIGALI**

Dear Chief Executive Officer,

**RE: Transmission of Public Private Partnership Project of Installation of PSA Oxygen plants in 11 Hospitals**

In a bid to find out a solution to the problem in regard to medical oxygen production and distribution within our health facilities where supply of medical oxygen does not meet public demand;

The Government of Rwanda, through the Ministry of Health and its partners, is working to expedite improved respiratory care capacity by strengthening oxygen delivery systems across the public hospitals for improved readiness in response to the COVID-19 pandemic as we consider provision of oxygen as an urgent need to ensure provision of services within our health facilities and for which there are no alternatives and safe delivery of medical oxygen to patients requires robust diagnosis and supply systems;

To understand the situation, the Ministry of Health and Rwanda Biomedical Centre (RBC) in partnership with Clinton Health Access Initiative (CHAI) conducted a rapid respiratory care capacity assessment in September 2020 to assess the operability of existing respiratory care equipment on oxygen generation capacity, medical equipment, respiratory care accessories and clinical capacity for oxygen therapy within health facilities. The findings showed gaps in both infrastructure and human resource capacity.

Considering that the private sector has expressed interest in this area of medical oxygen production in the search for solutions to these enormous needs, the Ministry of Health wishes to explore Public Private Partnership in installing 11 PSA oxygen plants in 11 identified hospitals. I am therefore pleased to submit the attached study that assessed and analysed the viability of the project for your good office do a necessary review for further steps in line Public Private Partnership Law and guidelines in place.

Dear CEO, I wish by the same occasion to request that this file be also tabled in the next PPP Steering Committee for consideration. If approved, we shall proceed with a Request for Proposals in order to select the best offer for the health sector.

For further information, our contact person is **Dr. Corneille NTIHABOSE, Head of Clinical and Public Services Department/MOH available at email: corneille.ntihabose@moh.gov.rw or Phone Number: 0788600997**.

Thank you for your usual collaboration.

Sincerely,

**Dr. NGAMIJE M. Daniel**
**Minister of Health**

**Cc:**

- **Hon. Minister of Finance and Economic Planning**
- **Hon. Minister of State in Charge of Primary Health Care**
- **Permanent Secretary/MOH**
- **Director General of Rwanda Biomedical Centre**

REPUBLIC OF RWANDA

MINISTRY OF HEALTH

# Public Private Partnership Project of Installation of PSA Oxygen plants in 11 Hospitals

May 2021

## Preface

In a bid to find out a solution to the problem in regard to medical oxygen production and distribution within our health facilities where supply of medical oxygen does not meet public demand;

The Government of Rwanda, through the Ministry of Health and its partners, is working to expedite improved respiratory care capacity by strengthening oxygen delivery systems across the public hospitals for improved readiness in response to the COVID-19 pandemic as we consider provision of oxygen as an urgent need to ensure provision of services within our health facilities and for which there are no alternatives and safe delivery of medical oxygen to patients requires robust diagnosis and supply systems;

To understand the situation, The Rwanda Ministry of Health and Rwanda Biomedical Centre (RBC) in partnership with Clinton Health Access Initiative (CHAI) conducted a rapid respiratory care capacity assessment in September 2020 to assess the operability of existing respiratory care equipment on oxygen generation capacity, medical equipment, respiratory care accessories and clinical capacity for oxygen therapy within health facilities. The findings showed gaps in both infrastructure and human resource capacity.

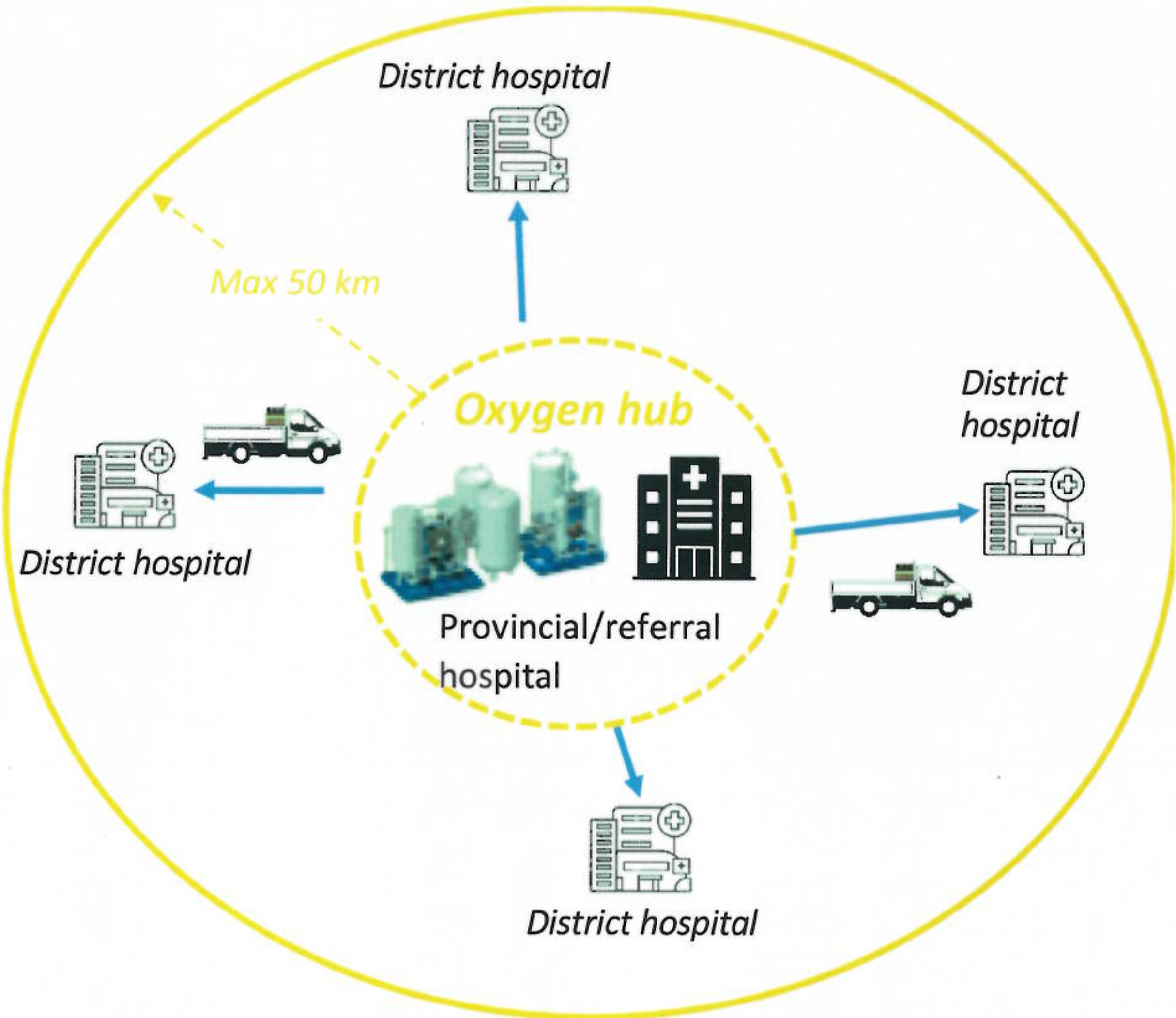
Findings revealed that there are a significant number of broken-down equipment within health facilities across the country. Additionally, the capacity of Biomedical engineers and Technicians trained on maintenance and repair of respiratory care equipment requires additional in-service refreshers to keep up to date with changes in technology and COVID-19 use, for which the lack of spare parts has been highlighted as a key reason for non-functional equipment.

The present document is developed as a strategy which identifies a variety of barriers to sustainable access of medical oxygen in public and subsidized hospitals and showing key areas of intervention targeted in order to address these barriers and scale up access to safe medical oxygen across Rwanda with a clear roadmap for increasing access to medical oxygen in all concerned hospitals.

Considering that the private sector has expressed interest in this area of medical oxygen production in the search for solutions to these enormous needs, the Ministry of Health wishes to explore Public Private Partnership in setting up oxygen production units in hospitals to be selected strategically. The attached study assessed and analyzed the viability of the project thus can serve as guide in the PPP engagement process.

MINISTRY OF HEALTH

**Dr. NGAMIJE M. Daniel**
**Minister of Health**


District hospital
Max 50 km
Oxygen hub
District hospital
District hospital
Provincial/referral hospital
District hospital

## I. Project Team

The following road map was developed in partnership with the Ministry of Health and the Rwandan Biomedical Center. The MOH received technical support from CHAI throughout the drafting of this road map. Several national and international documents were reviewed and consulted, and many national coordination meetings took place to incorporate recommendations. The Ministry greatly appreciates the commitment of the various distinguished individuals who have contributed in the preparation of this strategy. They include:

| | |
|---|---|
| MOH | Dr. Corneille NTIHABOSE |
| MOH | Dr. Nathalie UMUTONI |
| MOH | Donatien BAJYANAMA |
| RBC | Eng. Francine UMUTESI |
| CHAI | Diana KIZZA |
| CHAI | Hyacinthe MUSHUMBAMWIZA |

## II. Table of Contents

## III. Acronyms

| | |
|---|---|
| BME | Biomedical Engineer |
| CAPEX | Capital Expenditures |
| CBHI | Community Based Health Insurance |
| CHUB | University Teaching Hospital of Butare |
| CHUK | University Teaching Hospital of Kigali |
| CPAP | Continuous Positive Airway Pressure |
| DH | District Hospital |
| ECG | Electrocardiography |
| HC | Health Center |
| HF | Health Facility |
| HSSP 4 | Health Sector Strategic Plan 4 (2018/19 – 2023/24) |
| ICUs | Intensive Care Unit |
| KFH | King Faisal Hospital |
| kW | Kilo-Watts |
| L | Liters |
| LPM | Liters Per Minute |
| MEMMS | Medical Equipment Maintenance Management System |
| MOH | Ministry of Health |
| NPV | Net Present Value |
| OPEX | Operating Expenditures |
| PH | Provincial Hospital |
| PSA | Pressure Swing Adsorption |
| RBC | Rwanda Biomedical Center |
| REG | Rwanda Energy Group |
| RH | Referral Hospital |
| RMH | Rwanda Military Hospital |
| RMH 2 | New oxygen plant to be built at Rwanda Military Hospital |
| RWF | Rwandan Franc |
| SOP | Standard Operating Procedure |
| $SpO_2$ | Blood Oxygen Saturation Level |
| USD | United States Dollar |
| WHO | World Health Organization |
| | |

## IV. Executive Summary

**Medical oxygen is an essential drug for which there are no alternatives.** It is required to treat hypoxemia and to conduct safe surgeries and is included on the World Health Organization (WHO) List of Essential Medicines. In Rwanda, it is designated by the Ministry of health (MOH) of Rwanda as an essential inhalation medicine. Hypoxemia is associated with a range of acute and chronic diseases which are major causes of preventable deaths in both children and adults in Rwanda. These include pneumonia, bronchiolitis, asthma, chronic obstructive pulmonary disease (COPD), malaria, sepsis, anemia and complications from surgery. When severe hypoxemia is not quickly diagnosed and addressed, it can lead to death.

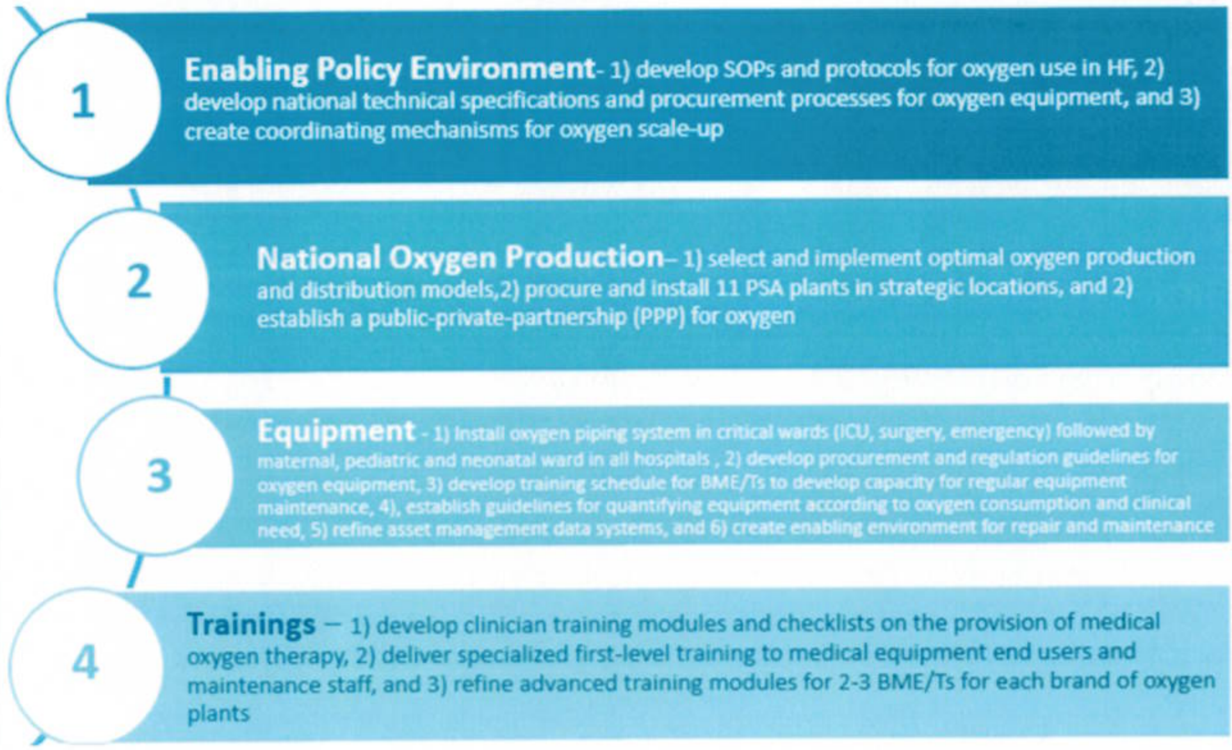
**Safe delivery of medical oxygen to patients requires robust diagnosis, supply, and maintenance systems.** Health facilities need 1) equipment to measure patient oxygen saturation levels (e.g., pulse oximeters, vital sign monitors), 2) oxygen supply sources (oxygen plants, concentrators or cylinders), and 3) a variety of accessories and consumables to administer oxygen to patients. Clinical staff must know how to diagnose and administer oxygen therapy. Technical staff must know how to manage oxygen equipment.

**Public supply of medical oxygen does not meet public demand.** National consumption of oxygen in Rwandan public hospitals is reported at 6,760 cylinders (50L, 150 bar) per month. This does not include oxygen supplied directly via oxygen concentrators. 68% of consumed oxygen (4,597 cylinders per month) is provided by oxygen plants in public hospitals that produce oxygen for themselves and for certain peripheral hospitals, while the remaining 32% is privately sourced from suppliers, such as Karisimbi or Rwanda Oxygen. There are currently 13 oxygen plants in public hospitals, 11 of which are fully functional and have a maximum oxygen production capacity of 500 cylinders (50L) per day, or approximately 15,250 cylinders per month. However, these plants are producing on average 310 cylinders (50L, 150 bar) of oxygen per day, functioning at 64% of their total capacity. On average, oxygen is sold at RWF 300/L, though this price varies according to transportation costs and supplier.

**It is likely that public hospitals are procuring less medical oxygen than clinically needed.** This may be because clinicians are underdiagnosing hypoxemia or administering less oxygen than required for patients. Based on oxygen consumption rates of CHUK and Ruhengeri per bed by ward and overall bed occupancy rates, the national consumption of medical oxygen in Rwandan hospitals should be 15,067 cylinders (50L, 150 bar) per month, suggesting that current oxygen use in public hospitals is covering only 48% of the clinical need for oxygen. This ratio varies per province, with the Eastern and Western regions are "under-consuming" oxygen the most.

**A variety of barriers to sufficient and safe use of medical oxygen in public hospitals have been identified.** Regarding **protocols and SOPs,** there are gaps to ensure oxygen supply is well managed and clinicians know and follow protocols and guidelines. In addition, the current medical equipment procurement process does not allow for standardization of equipment across hospitals, leading to inefficiencies in equipment operation and maintenance. Significant **financial barriers** have been identified. Current oxygen therapy tariffs set by MOH do not cover the cost of oxygen for hospitals, thus dis-incentivizing oxygen use in health facilities. Many hospitals do not have adequate maintenance budgets to cover the maintenance costs, some of which include expensive service contracts with private providers. High electricity costs charged to hospitals drive up the costs of oxygen supply sources like plants and concentrators. In addition, long distances from oxygen supply sources means that hospitals in the East and West pay very high transportation costs. Another barrier is the **lack of functional equipment and infrastructure** in hospitals to support medical oxygen use. Most hospitals do not have enough pieces of key equipment such as cylinders to meet patient demand. In addition, for some types of equipment (e.g., concentrators), there are high rates of non-functional equipment due insufficient maintenance and lack of spare parts. Finally, there are **human resources barriers**: a lack of maintenance staff in hospitals, and gaps in trainings for both clinical and maintenance staff.

**Four key areas of intervention are targeted in order to address these key barriers and scale up access to safe medical oxygen across Rwanda:**




A financial sustainability assessment has been carried out; **building additional plants and lowering the price for oxygen should be financially sustainable, as long as hospitals with oxygen plants have sufficient demand.** To ensure this demand, it will be essential to push peripheral hospitals to procure their oxygen from public oxygen plants first, and to allow plants to sell to private health facilities in case of excess capacity.

**The total initial investment (capital expenditures or CAPEX) cost of this plan is estimated at RWF 15 billion, while annual operating costs are estimated at RWF 4 billion per year.** Key project risks and corresponding mitigation strategies have been identified, and performance indicators for plan monitoring and evaluation have been developed and are at the end of this document.

## V. Introduction

In recent years, Rwanda has made significant strides in maternal and child health. The Maternal Mortality Ratio decreased from 476[1] in 2010 to 210/100,000[2] live births in 2015. The Infant Mortality Rate decreased from 50[3] in 2010 to 32/1,000[4] live births in 2015. Also, the Neonatal Mortality Rate declined from 27[5] in 2010 to 20/1,000[6] live births in 2015. Although progress has been made, there is a need to scale up efforts to avoid preventable deaths, especially for women and children. As stated in the Fourth Health Sector Strategic Plan (HSSP 4), Rwanda prioritizes maternal and child health problems, especially those that are preventable or treatable with proven, cost-effective interventions.

Hypoxemia disproportionately affects the most vulnerable. Indeed, hypoxemia is associated with two of the top ten causes of mortality of under-five year-olds in health facilities in Rwanda: acute respiratory infections (33.5% of deaths) and pneumopathies (3.1% of deaths).[7]

Hypoxemia is most commonly diagnosed by pulse oximetry. Oxygen therapy is the primary treatment for hypoxemia and is needed across the health system: from the intensive care unit (ICU) to pediatric wards, gynecology, obstetrics, operating theaters and emergency departments.

There is no alternative treatment to oxygen. As a result, medical oxygen is included on the World Health Organization (WHO) List of Essential Medicines. In Rwanda, the MOH has designated medical oxygen as an essential inhalation medicine that must be provided in all referral, provincial and district hospitals.[8]

Furthermore, medical oxygen is arguably the most important treatment available for COVID-19—which has increased the global hypoxemia burden and more than doubled the volume of oxygen needed to meet clinical demand with volumes of up to 30LPM needed per patient over 14 days.[9]

---

[1] DHS 2010
[2] DHS 2015
[3] DHS 2019
[4] DHS 2015
[5] DHS 2010
[6] DHS 2015
[7] Ministry of Health, HMIS 2016
[8] Rwanda National List of Essential Medicines for Adults, 6th edition, 2015
[9] WHO, Oxygen sources and distribution for COVID019 treatment centers, interim guidance

Since March 2020, the pandemic has exposed the alarmingly limited availability of oxygen in much of the world. Weak, unreliable oxygen systems have become a critical bottleneck in pandemic response efforts. Per World Health Organization (WHO) treatment guidelines, COVID-19 patients require two to six times more oxygen than the average ICU patient. Rwanda identified its first case of COVID-19 on March 14, 2020. Since then, the country has reported 24,262 cases and 328 deaths. A surge in transmission was reported over the four weeks leading up to January 21, 2021, accounting for 34% of all cases and 57% of deaths since the first reported case. Most of the reported cases were in Kigali City, where 117 travelers from 26 countries tested positive, mainly from Tanzania, Burundi, Kenya, and Nigeria. A majority of cases (90%) are managed via tracked home-based care, and treatment centers have reported an average of 67% bed occupancy rate.

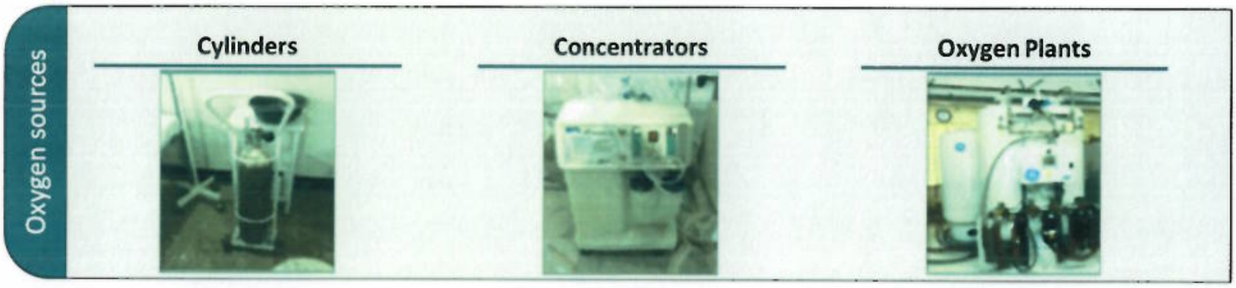
Although oxygen therapy is a basic requirement to save lives, many barriers remain to delivering appropriate treatment across public hospitals in Rwanda. The MOH recognizes these challenges, and in line with the HSSP 4, seeks an integrated approach to resolve the persistent bottlenecks to adequate oxygen therapy delivery in hospitals. This strategy provides an implementation framework for addressing these challenges and scaling up medical oxygen use and availability in hospitals. Further, it intends to be a guide for resource mobilization.

### i. Hypoxemia Diagnosis and Oxygen Therapy

**Diagnostic tools**, such as pulse oximeters or other multi-parameter monitors are required to diagnose and monitor hypoxemia. Patient monitors and pulse oximeters should be allocated according to the expected prevalence of hypoxemic patients which require continuous monitoring. Adequate fingertip pulse oximeters should be allocated according to screenings needs in outpatient wards.


### ii. Oxygen Supply Systems

Medical oxygen can be supplied to patients by several types of sources - bedside cylinders, concentrators or oxygen plants.




**Oxygen concentrators** are small and light enough to be wheeled around wards as needed, though are generally stationary at the bedside. These devices are 100% reliant on electricity and also depend on quality and consistent preventative maintenance to ensure an acceptable oxygen output. Most oxygen concentrators have flow rates ranging from 3 to 10 LPM, which makes them suitable for a broad range of patients, with the exception of certain critically ill patients, e.g., COVID-19 patients who require mechanical ventilation. The oxygen concentrator market is fragmented, with dozens of manufacturers, the majority of which are based in the United States or China. The main brands reported on the market in Rwandan hospitals are Airsep, Invacare and Philips Everflo.

**Pressure Swing Adsoprtion (PSA) oxygen plants** PSA plants themselves (~50 cylinders / day, (50L, 150 bar)) typically cost USD $100,000--including the plant, the cylinder filling station and shipping. When taking into account all additional investments required for PSA plants, such as a backup generator, pipeline installation, delivery truck and cylinders, the total cost is approximately $350,000.[10] Annual operating expenditures range from 30-70% of the initial investment cost and includes electricity, manpower, and repair & maintenance.

For large hospital with reliable electricity, PSA plants could be a cost-effective solution – though dependent on highly robust maintenance systems and electricity costs. At Ruhengeri hospital, the cost savings achieved by producing oxygen locally compared with the previous supply model (cylinders sourced from outside) were able to pay back the capital expenditures of the PSA plant in seven years. Oxygen plants are designed to function 24 hours a day and can last up to 25 years if properly maintained. Excess capacities can be stored in cylinders and supplied to surrounding hospitals at a charge.

**Air Separation Unit (ASU) oxygen plants** – ASUs produce bulk, liquid oxygen and are typically used for heavy industry. They are typically offsite and require electricity to operate. There is currently no ASU plant in Rwanda. Plants are energy intensive and must be located off-site due to potential hazards. Thanks to its higher density, liquid oxygen is cheaper to transport over long distances compared with gaseous oxygen. Liquid oxygen plants are typically established for industrial purposes, medical use drawing from an ASU plant is secondary. ASU plants require much higher initial investment costs than PSA plants (several million US$) and are far more energy

[10] Ruhengeri hospital oxygen plant cost (AirSep brand, AS-K-900-HMFM model)

intensive in production. Liquid oxygen can be a cost-effective option for hospitals where the demand is high enough to make bulk supplies cost-effective, and where point of use is within reasonable proximity to a liquid plant or depot. At the health facility level, liquid oxygen can be stored using a tank and a vaporizer connected to an oxygen piping system.

**Cylinders** - Given the weight of cylinders (78 kg for a 50L 'J' size cylinder), transporting cylinders over long distances can become prohibitively expensive when regular refills are required. Therefore, cylinders are most useful where a nearby refilling point is available and transportation infrastructure is reliable. Cylinders can be placed by the patient **bedside** or can be used as a central medical oxygen source in a cylinder **manifold system** (a group of cylinders) in hospitals that have centralized pipeline infrastructure for delivering gases to patient beds. Importantly, thanks to the high pressure inside the tank, oxygen from cylinders can be administered at flow rates of up to 25 LPM, making them suitable for treating the most critically ill patients, including COVID-19 patients.

**Electricity availability** – Oxygen production is very energy-intensive. It is critical that any facility delivering oxygen to patients be connected to a reliable source of electricity, particularly those that have an on-site PSA plant or utilize bedside concentrators. A recent BME assessment found that all surveyed facilities were connected to grid electricity and 88% of facilities reported having a backup generator. The only facilities that reported not having a backup generator were COVID-19 treatment centers.

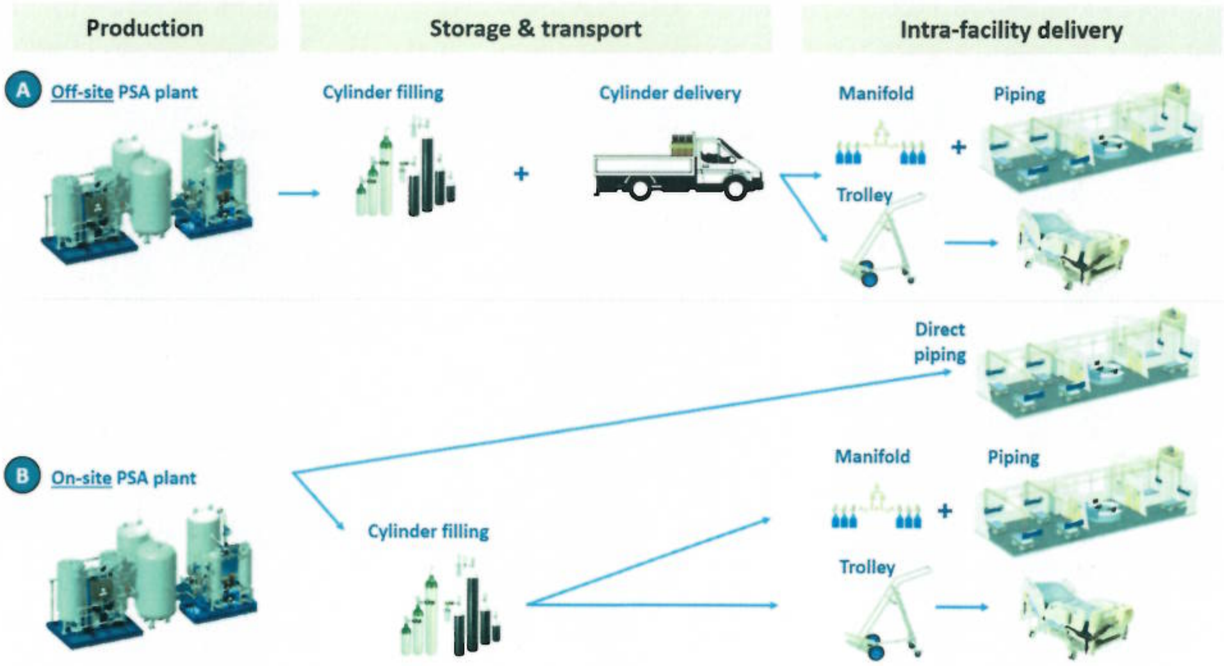
### iii. Oxygen Distribution

The various intra-hospital oxygen distribution models are presented in figure 1. **Medical gas pipeline infrastructure** can be a cost-effective investment in the long term for facilities that require high volumes of oxygen. Oxygen piping systems have design-life of up to 30 years, subject to detailed annual inspection as well as review of planned preventive maintenance records, detailed inspection, and an in-depth needs assessment every 5 years.[11] When the hospital has a comprehensive central pipeline network, the PSA plant can directly connect to oxygen piping (option B 'direct piping' in figure 1), thereby significantly reducing or eliminating the need for cylinders (most efficient option). When the PSA plant cannot be directly connected to a central piping system, cylinders will be necessary. A booster compressor and a filling ramp are required to fill cylinders. In hospital with partial oxygen piping (option B 'manifold' in figure 1 below), the cylinders can be plugged to a manifold system outside of the hospital ward (second-best option).

[11] Department of Health, Health Technical Memorandum 02-01: Medical gas pipeline systems, London, 2006; and International Standard Organization, Medical gas pipeline systems — Part 1: Pipeline systems for compressed medical gases and vacuum, Edition 3, 2020.

In hospital without piping (option B 'trolley' in figure 1 below), the cylinders are placed at the patient bedside (least efficient option).

Figure 1 - Intra-hospital distribution models




## iv. Additional Equipment, Consumables and Spare Parts

**Accessories**, such as flowmeters, flow splitters, and oxygen blenders, are used to ensure appropriate and rational delivery of oxygen and to prevent the risk of improperly delivered oxygen therapy, especially for newborns. Furthermore, they can allow multiple patients to be treated at the same time. Humidifiers are also required during oxygen therapy for flows ≥4 LPM, when delivery bypasses mucosa (e.g. when nasopharyngeal catheters are used), or for oxygen supplied from cylinders. Pressure regulators, gauges, flowmeters and humidifiers are accessories required for oxygen cylinders.

**Consumables**, including airway interfaces such as nasal cannula and oxygen tubing, should be appropriately sized and are intended for single use to deliver oxygen to the patient. In the event that these consumables are reused, appropriate disinfection procedures must be followed.

**Spare and replacement parts**, such as probes and batteries for pulse oximeters and multi-parameter monitors and all filters for oxygen concentrators, are key to proper maintenance. They can vary in design and life expectancy, require regular replacement, and usually are not interchangeable between different brands and models.

**Additional respiratory devices**, such as continuous positive airway pressure (CPAP) devices, resuscitation devices, intensive care ventilator machine, and anesthesia machines, may be needed during oxygen therapy for certain medical applications, and the appropriate clinical guidelines should be referenced.

**Maintenance tools** are instruments that assist with the analysis of oxygen sources or delivery interfaces, such as gas flow analyzers, oxygen analyzers, electrical safety analyzers. These can help to verify that the devices are functioning properly and can signal when maintenance is needed. They should be used to periodically monitor the functionality and/or quality of oxygen technologies and should be part of any oxygen supply solution.

## VI. Situational Analysis

### i. Medical Oxygen Supply

In public hospitals in Rwanda, oxygen is 1) produced by oxygen plants in referral hospitals, 2) procured in cylinders from private, in-country suppliers and 3) produced by oxygen concentrators within hospitals. These various options are described in more detail below.

#### a. Oxygen plants in referral hospitals

Medical oxygen is primarily produced in Rwanda using 18 small- to medium-size PSA plants. Most of them are located at the largest referral hospitals in Kigali, though some are at provincial hospitals. PSA plants' current national potential production capacity is estimated at 175 million liters per month maximum (~ 26,000 large cylinders ["J" size; 50L]). **Given that PSA plants rarely operate 24h per day, the actual production capacity is likely much lower.**

Table 1 - Existing oxygen plants and their maximum production capacity as of April 2021[12]

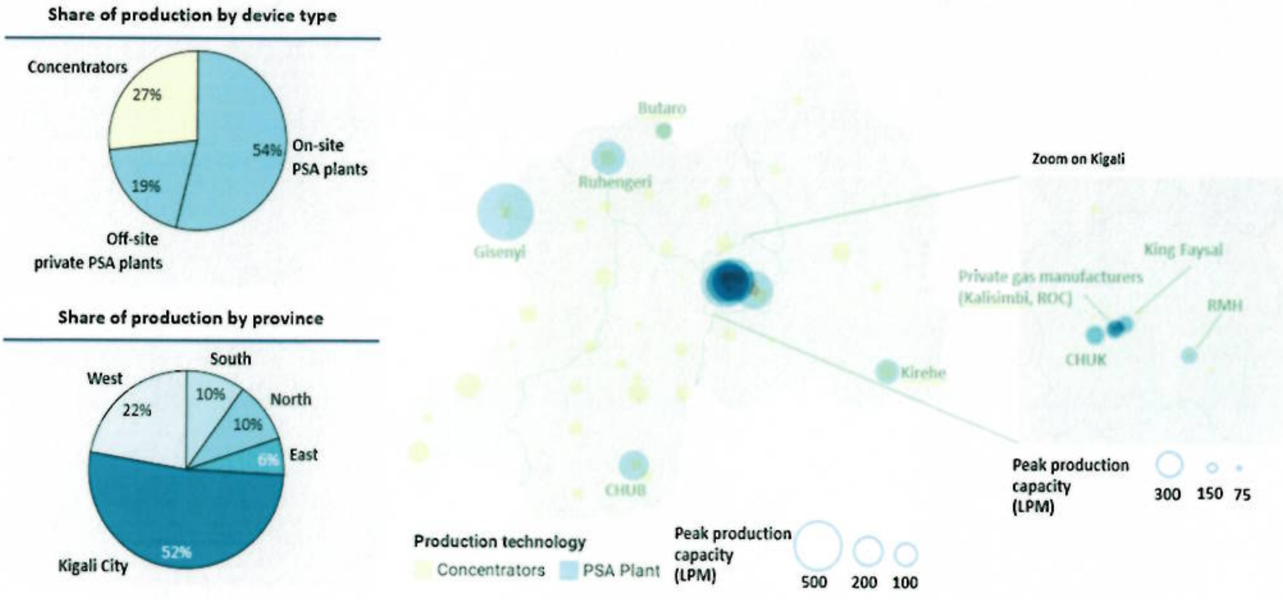
| Plant | PSA plant brand | Ownership | Max Capacity (Nm3/h) | Max Capacity (cylinder / day) | Installation year | Status |
|---|---|---|---|---|---|---|
| Ruhengeri | Airsep | Public | 14 | 50 | 2014 | Functional |
| Rwinkwavu | OGSI | Public | 2 | 8 | 2016 | Non functional |
| Butaro | OGSI | Public | 3 | 11 | 2011 | Functional |
| KFH I | Airsep | Public | 11 | 40 | 1998 | Functional |
| KFH II | Oxymat | Public | 23 | 80 | 2010 | Non functional |
| Kirehe | Novair | Public | 7 | 26 | 2019 | Functional |
| CHUB I | Oxymat | Public | 11 | 40 | 2017 | Functional |
| CHUB II | INMATEC | Public | 6 | 20 | 2013 | Functional |
| RMH | Oxymat | Public | 18 | 62 | 2008 | Functional |
| CHUK I | Oxymat | Public | 28 | 100 | 2018 | Functional |
| CHUK II | Oxymat | Public | 17 | 60 | 2012 | Functional |
| CHUK III | CPO12 | Public | 6 | 20 | 2006 | Functional |
| Nyarugenge | | Public | 17 | 60 | 2021 | Functional |
| Gisenyi | Hanof | Private | 43 | 150 | 2020 | Functional |
| Rwanda Oxygen company | n.a. | Private | 3 | 40 | n.a. | Functional |
| KALISIMBI Plant 1 | n.a. | Private | 17 | 80 | n.a. | Functional |
| KALISIMBI Plant 2 | n.a. | Private | 28 | 100 | n.a. | Functional |
| KALISIMBI Plant 3 | n.a. | Private | n.a. | n.a. | n.a. | Functional |

| | Nm3 /h | Cylind. /day |
|---|---|---|
| **Total capacities (functional plants only)** | **230** | **859** |
| Out of which: | | |
| *Public PSA plants* | *139* | 489 |
| *Private PSA plants* | *91* | 370 |

As shown in figure 2, current oxygen production capacities are concentrated in Kigali, which creates equity issues and access challenges for patients living in other regions -about half of the available capacities are located in the capital city which hosts just 10% of the total population. Many large provincial hospitals lack reliable access to oxygen and need to organize expensive deliveries of oxygen cylinders from Kigali.

[12] Unless otherwise specified, cylinders refer to 'J' size cannisters containing approximately 6,800 liters of compressed medical oxygen at 137 bars. Ruli, Rwamagana, Rwinkwavu, Ngarama, Nyamata, and Nemba hospitals also have small-size oxygen generators (max 2 cylinders per day). However, these generators are old and currently not functional.

Figure 2 – Overview of existing oxygen production capacities (PSA plants & concentrators)




Ruhengeri and CHUB hospitals produce more oxygen than they need for their own patients and sell their excess production to other hospitals. However, pricing is not equitable across facilities since hospitals pay 300RWF/L regardless of whether or not they include transportation services, depending on whether existing routes exist and whether it is profitable to include transport in order to provide an incentive for oxygen purchase.

### b. Private suppliers

As shown in table 1 above, there are several **private medical oxygen suppliers** in Rwanda: Kalisimbi company and Rwanda Oxygen company are producing medical-grade oxygen through privately owned PSA plant. Clabuso Ltd, and Rusizi Trading are distributing oxygen cylinders that are produced by the aforementioned private producers. In 2018, 48 hospitals reported that they purchase approximately **2,163 cylinders (50L size) per month** from private suppliers. Pricing is dictated by the largest private supplier, Kalisimbi, and ranges from 250 RWF/L to 370 RWF/L depending on transport (see table 2 below). Transport costs are determined on a case by cases basis depending on distance from supplier, volume of order, nearby clients and are sometimes provided free or at a discount in order to provide an incentive to purchasers. Hospitals purchase oxygen directly from these private suppliers; there is no grouped (regional or national) purchasing agreement. For hospitals that do not have a sufficient number of cylinders, private providers do lend cylinders to the hospitals on good will with no leasing or fee structure.

Table 2 – Oxygen pricing in Rwanda from oxygen producers, excluding distributors (2020)

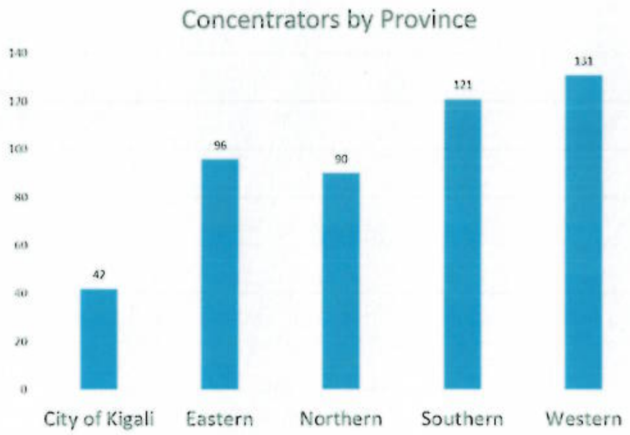
| Oxygen producer | Private or Public? | Number of hospitals it sells oxygen to | Price charged to other hospitals for oxygen (RWF / L at 150 bar) | Transport costs included in price? |
|---|---|---|---|---|
| **CHUB** | Public | 4 | 300 | YES |
| **Ruhengeri** | Public | 10 | 300 | NO |
| **Gisenyi** | PPP | 13 | 250 | YES |
| **Karisimbi** | Private | 20 | 280 – 370 | YES and NO (depends on hospital) |
| **Rwanda Oxygen** | Private | 4 | 250 – 300 | NO |

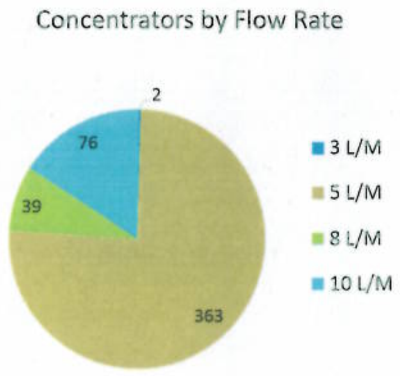
### c. Oxygen concentrators

Hospitals also rely on oxygen concentrators to produce on-site and deliver medical oxygen to patients' bedside. The prevalence and use of concentrators vary widely across facilities as they have faced challenges with sourcing of spare parts, maintenance, and aging equipment. Because of this, they are primarily used as a backup source of oxygen. A recent equipment assessment found 480 concentrators across all facilities, but only 260 were functional.

COVID-19 treatment centers accounted for 7%, or 35, of the total available concentrators. A majority of the available concentrators lack sufficient flow rates to be able to treat COVID-19 patients (a concentrator capable of 10 LPM would be needed for severe COVID patients and up to 30 LPM for critical ones). Only 45 of the available concentrators are functional and have flow rates sufficient for COVID patients.[18] With the available concentrators, across all provinces, only 45 severe COVID-19 patients could be treated at the same time with high-flow concentrators, and no critical COVID-19 patients could be treated. There were an additional 215 functional concentrators with flow rates below 10 LPM, which are only suitable for pediatric patients. Since there are no flow-splitters available at surveyed facilities, this would allow only an additional 215 pediatric patients to be treated simultaneously.

Figure 3 – Total concentrators by province and flow rate




Source: BME assessment, October 2020

## ii. Medical Oxygen Needs

In February 2018, **6,760 cylinders (50L, 150 bar) per month were consumed across all public hospitals** to meet patient demand for medical oxygen.[13] This estimation did not include the medical oxygen supplied directly via oxygen concentrators. **Oxygen consumption appears to have increased to 12,000 cylinders per month in September 2020, right after the peak of the first wave of COVID-19 cases.**[14]

Nationally, 68% of the cylinders on average are supplied from oxygen plants based out of public hospitals, while the remaining 32% are purchased from private suppliers. However, this varies across provinces: in the Eastern Province, 100% of medical oxygen is procured from private suppliers. In Kigali city, publicly produced medical oxygen covered more than 80% of reported purchases.

However, it is likely that hospitals are procuring **less medical oxygen than actually clinically needed and may be underdiagnosing hypoxemia or administering less oxygen than required due to the difference between the expected need based on disease burden and actual consumption recorded**. To understand the full extent of the medical oxygen needs in Rwanda, a national quantification exercise was performed from Oct-Nov 2020. Total oxygen need was calculated using hypoxemia prevalence assumptions for different bed and patient types, bed turnover rate, typical flowrate, and oxygen therapy duration for each bed type. The government's ICU expansion plan was taken into account. To account for the different trajectories that the

[13] CHAI assessment, 2018
[14] BME Assessment, September 2020

COVID-19 pandemic could take, three scenarios were based on hypothetical bed occupancy rates in the isolation ward and ICU.

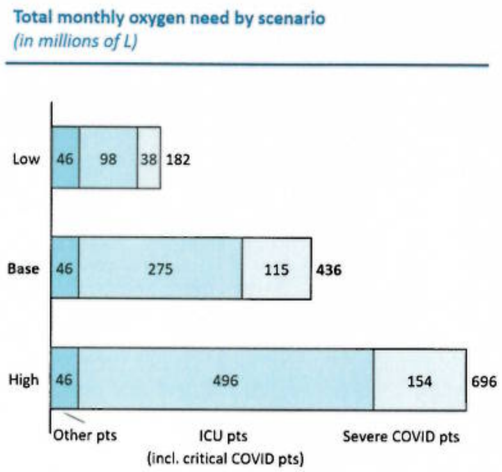
**Depending on the COVID-19 scenario, total average monthly oxygen needs could range between 182 million (27,000 cylinders) and 696 million liters (102,000 cylinders). In the base scenario, 436 million liters are needed every month (64,000 cylinders).**

Figure 4 – Total monthly oxygen needs by COVID-19 scenario

*Clinical assumptions*

| | % of beds utilized by COVID patients | | Average flow rates (LPM) | | Average oxygen therapy durations (days) | |
|---|---|---|---|---|---|---|
| | ICU | COVID ward | ICU* | COVID ward | ICU* | COVID ward |
| Low | 5% | 25% | 9,7 | 10 | 4,5 | 7 |
| **Base** | **25%** | **75%** | **18,9** | **10** | **6,5** | **7** |
| High | 50% | 100% | 24,7 | 10 | 9 | 7 |

*Note: the ICU's flow rate and duration of oxygen therapy are shown as weighted averages between the COVID critical patients (flow rate: 30 LPM, 14 days of treatment) and the other ICU patients (8 LPM, 4 days of treatment)

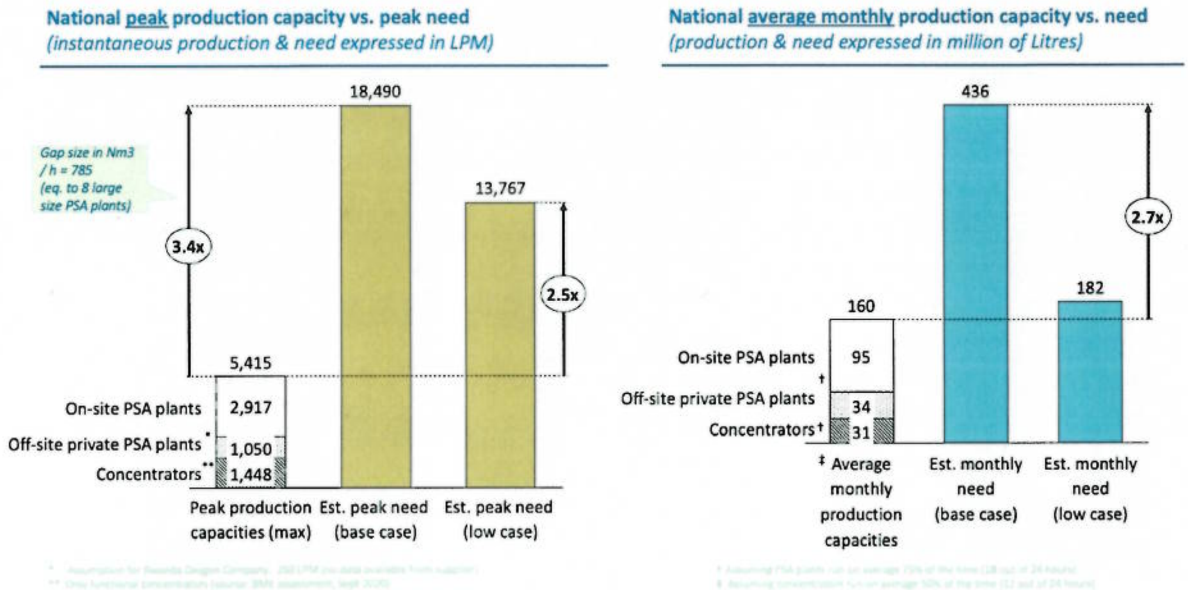



Source: Quantification exercise, November 2020

A spatial analysis shows that the oxygen need is relatively evenly spread out geographically (see Appendix 1), with several provincial and district hospitals exhibiting high need due to their size and number of admissions per year.

As shown in figure 5 below, oxygen production would have to triple to meet the peak instantaneous need, described in Figure 5, in the base case scenario.

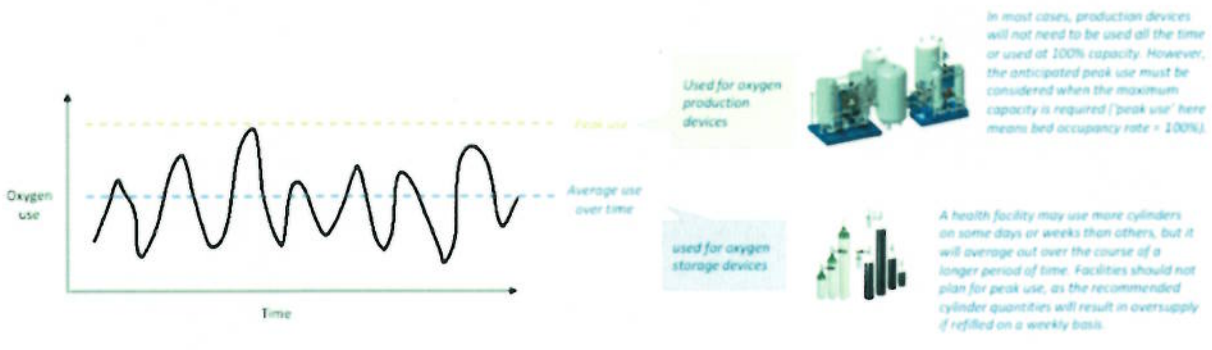
Figure 5 – Oxygen gap analysis (need vs. peak and average production capacities)




Source: Quantification exercise, November 2020

To avoid oxygen shortage during a surge in patient number, peak instantaneous oxygen need, that is the oxygen need when the health facility reach 100% occupancy rate, should be taken into account when calculating the required production capacity of a PSA plant (Figure 6 below).

Figure 6 – Peak instantaneous oxygen needs vs. average oxygen use over time




Source: PATH

### iii. Status of piping network

**In Rwanda, recent investments have increased the proportion of hospitals that have oxygen piping.** As of April 2021, out of the 54 hospitals surveyed, 26 had partial or comprehensive piping, while 28 had no piping. Table 3 shows the detailed status of each hospitals.

All the referral and provincial hospitals, with the exception of Kibungo (314 beds), Kinihira (144 beds) and Kibuye (218 beds) hospitals, have at least one ward with piped oxygen with manifold system. In the largest hospitals (e.g., RUHANGO, CHUK, King Faysal, RMH and RUHENGERI), most beds are connected to a terminal wall outlet. See table 3 for a full breakdown of the piping status at all facilities.

**The vast majority of health facilities without piping are district hospitals**. Since all these facilities routinely admit critical patients and given that the Government's ICU expansion plan aims to build intensive care capacities at the district hospital level, the need to equip these facilities with piped oxygen becomes obvious.

Table 3 – Current piping status at all facilities by region

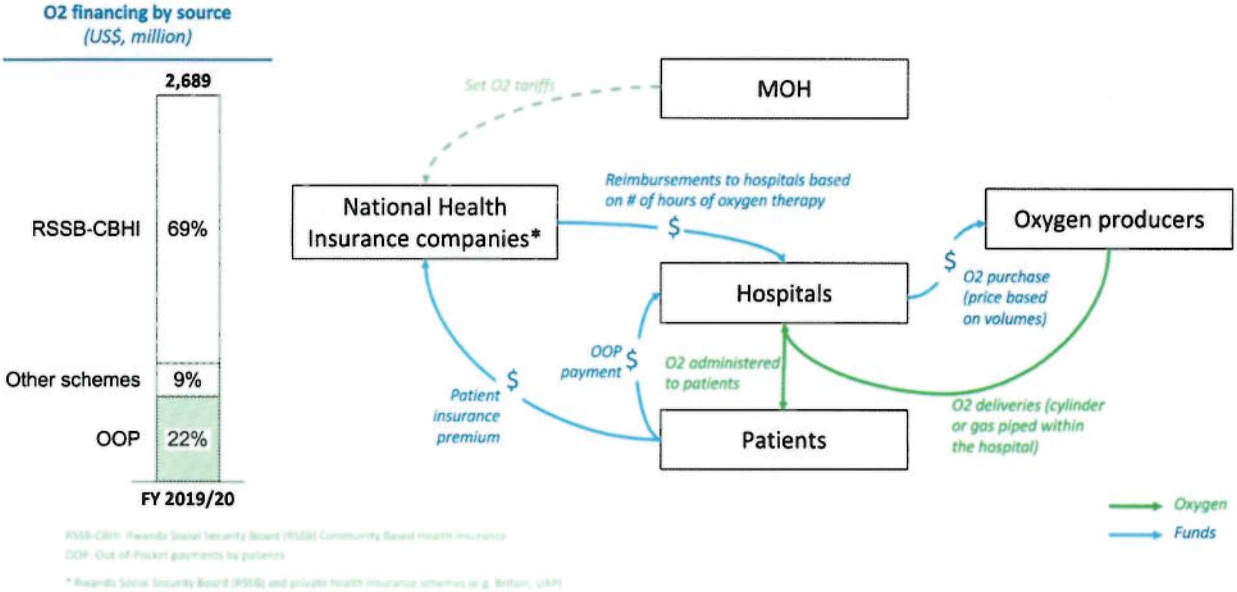
| Province | No. | Hospital | Piping Status | Wards/Departments piped |
|---|---|---|---|---|
| Western | 1 | KABAYA | Not piped | N/A |
| | 2 | MUHORORO | Not piped | N/A |
| | 3 | SHYIRA | Piped | Operating theater, neonatology, pediatrics, maternity, internal medicine, surgery, emergency |
| | 4 | GISENYI | Not piped | N/A |
| | 5 | MURUNDA | Not piped | N/A |
| | 6 | KIBUYE | Not piped | N/A - COVID-19 ward under renovation and piping process |
| | 7 | KIRINDA | Not piped | N/A |
| | 8 | MUGONERO | Not piped | N/A |
| | 9 | KIBOGORA | Not piped | N/A |
| | 10 | BUSHENGE | Piped | Emergency, operating theater, neonatology, internal medicine, maternity, pediatric, surgery |
| | 11 | GIHUNDWE | Not piped | N/A |
| | 12 | MIBILIZI | Not piped | N/A - COVID-19 ward under construction and piping process |
| Southern | 13 | REMERA RUKOMA | Not piped | N/A |
| | 14 | KABGAYI | Not piped | N/A |
| | 15 | GITWE | Not piped | N/A |
| | 16 | RUHANGO | Piped | All departments except COVID-19 ward |
| | 17 | NYANZA | Not piped | N/A |
| | 18 | KABUTARE | Not piped | N/A |
| | 19 | GAKOMA | Not piped | N/A - COVID-19 ward under construction process |
| | 20 | KIBILIZI | Not piped | N/A |
| | 21 | MUNINI | Not piped | N/A |

| | | | | |
|---|---|---|---|---|
| | 22 | KADUHA | Not piped | N/A |
| | 23 | KIGEME | Not piped | N/A |
| | 24 | CHUB | Piped | Emergency, operating theater, neonatology, maternity, pediatric |
| Eastern | 25 | NYAMATA | Piped | Neonatology, operating theater |
| | 26 | RWAMAGANA | Piped | COVID-19 ward |
| | 27 | GAHINI | Not piped | N/A |
| | 28 | KIBUNGO | Piped | COVID-19 ward |
| | 29 | KIREHE | Piped | All departments except internal medicine |
| | 30 | RWINKWAVU | Piped | Operating theater, neonatology, pediatric, emergency, maternity, internal medicine |
| | 31 | KIZIGURO | Piped | Operating theater, neonatology, maternity, pediatric |
| | 32 | NGARAMA | Piped | Neonatology |
| | 33 | NYAGATARE | Piped | Operating theater, neonatology, maternity, COVID-19 ward |
| | 34 | GATUNDA | Piped | Operating theater, neonatology, maternity, internal medicine |
| Northern | 35 | RUTONGO | Not piped | N/A |
| | 36 | RULI | Not piped | N/A |
| | 37 | KINIHIRA | Piped | Operating theater, neonatology, maternity, pediatrics, internal medicine, surgery but manifold is only for operating theater |
| | 38 | BYUMBA | Piped | Operating theater, neonatology, emergency, maternity, pediatric, surgery |
| | 39 | BUTARO | Piped | All departments except COVID-19 ward |
| | 40 | NEMBA | Piped | Neonatology, intensive care |
| | 41 | RUHENGERI | Piped | Operating theater, neonatology, ICU, emergency, maternity, recovery except COVID-19 ward |
| City of Kigali | 42 | KIBAGABAGA | Piped | Operating theater, neonatology, emergency, maternity, pediatrics, internal medicine |
| | 43 | MASAKA | Not piped | N/A |
| | 44 | MUHIMA | Not piped | N/A |
| | 45 | KACYIRU | Piped | Neonatology, maternity |
| | 46 | CARAES NDERA | Piped | Neurology |
| | 47 | CHUK | Piped | All departments |
| | 48 | RMH | Piped | All departments except COVID-19 ward |
| | 49 | KINGFAYSAL | Piped | All departments |
| | 50 | NYARUNGEGE DH | Piped | All departments |
| | 51 | KANYINYA TREATMENT CENTER | Piped | All departments |

## iv. Oxygen therapy reimbursement

As shown in diagram 1 below, in FY2019/20, an estimated RWF 2.6 billion of recoverable costs linked to oxygen therapy were claimed in Rwanda. Insurances, mainly the Rwanda Social Security Board's (RSSB) Community Based Health Insurance (CBHI), covered nearly 80% of that amount.[15] Just 22% of those oxygen therapy costs were directly borne by patients through out-of-pocket payment. The fact that oxygen therapy is, to a large extent, covered by existing health insurance schemes is a strong foundation upon which a nationwide oxygen access strategy can be built.

Diagram 1 – 2019-20 oxygen financing by source & oxygen financing flows




Insurance claims are calculated by hours of oxygen therapy as it is seen as a more convenient way to capture the data at the point of care.

Table 4 – Current oxygen tariffs by insurance scheme

| Insurances | Tariff (RWF / hour) |
|---|---|
| RSSB-CBHI | 635 |
| RSSB-RAMA | 1,125 |
| Private insurances | 1,035 |
| None insured | 1,656 |

[15] Source: Electronic Medical Records from 25 hospitals between July 2019 and June 2020. To obtain a national estimation, oxygen financing data were extrapolated to all hospitals in Rwanda using the average oxygen recoverable cost per admitted patient.

### v. Clinical guidelines & job aids

To ensure clinicians have appropriate guidance on best practice around medical oxygen therapy to patients, including screening and diagnosing hypoxemia and administering the appropriate quantities of medical oxygen, clinical guidelines on oxygen therapy should be available. However, currently there are no specific clinical guidelines and SOPs on hypoxemia diagnosis and oxygen administration. The current practice around oxygen therapy is guided by different existing clinical guidelines and non-standardized job-aids with limited details on oxygen therapy.

### vi. Quality assurance & SOP

Medical oxygen and other medical gases require regulation to ensure the minimum oxygen quality is maintained throughout the production process – from manufacturing to processing, packaging, and distribution. There are no available specific regulations, compliance manuals for good manufacturing practice and SOPs to ensure oxygen quality and patient safety. There are currently very few tools available at central or facility level to analyze the output of oxygen devices and ensure they are functioning properly. Furthermore, metrics related to the diagnosis of hypoxemia and delivery, training, equipment availability, equipment uptime and resource management are not readily available, aggregated or systematically analyzed.

## VII. Key Barriers

Many barriers must be addressed so that hospitals are able to provide patients with quality oxygen therapy. These include barriers related to protocols and guidelines, financial, equipment and infrastructure, supply chain systems, and human resources.

### i. Protocol and SOPs Barriers

**Procurement process**
Medical equipment procurement is currently carried out in a way that does not facilitate equipment standardization across hospitals, leading to inefficiencies in equipment operation and maintenance. There is a large variety of equipment brands and models across hospitals, leading to complications with the availability of spare parts and training for biomedical engineers and increases maintenance and repair costs. Two-stage procurement processes that could include supplier pre-qualification and assessment on criteria other than price are possible, but rarely implemented. If procurement was centralized and included the appropriate specifications, there is no reason why open bid tenders would be incompatible with equipment standardization. The real drivers are likely improper or incomplete specifications (which is what pre-qualification aims to address) and fragmented, small-scale procurements leading different hospitals or provinces buying different equipment from different suppliers.

**Clinical protocols**

Clinical guidelines in Rwanda have recently been reviewed and expected to be published in 2021. However, even with updated guidelines which reflect international and local best practices, 31% of surveyed hospitals reported that job aids and clinical protocols/guidelines for medical oxygen use are not available in wards. Job aids are not standardized and clinical competency in the diagnosis of hypoxemia and provision of oxygen therapy is not reviewed on a regular basis in order to drive and enforce usage of any available guidelines or job aids.

**Oxygen supply management SOPs**

Medical oxygen is a cross-cutting drug with complex logistics. However, there is a lack of clear SOPs for medical oxygen supply management. For example, hospitals are unclear on which department is responsible for medical oxygen supply.

**Oxygen quality control SOPs and / or certificates of analysis to control oxygen quality**

SOPs to ensure that oxygen produced in public plants is produced at the right purity, and that cylinders are filled at the right quantity are also lacking. In addition, there is no certification system to guarantee that private suppliers are supplying the required purity and quantity of oxygen in supplied cylinders. At present, some hospitals have independently purchased oxygen analyzers and are using them to correctly maintain and retire oxygen concentrators, however there is no systematic form of regulation, guidelines for follow-up protocol and assurance of resources to take correct actions, such as disposal.

**Policies on Data and Performance Management**

There are no clear SOPs or guidelines for what type of data should be tracked and how it should be used to manage financial, clinical or technical performance.

## ii. Financial Barriers

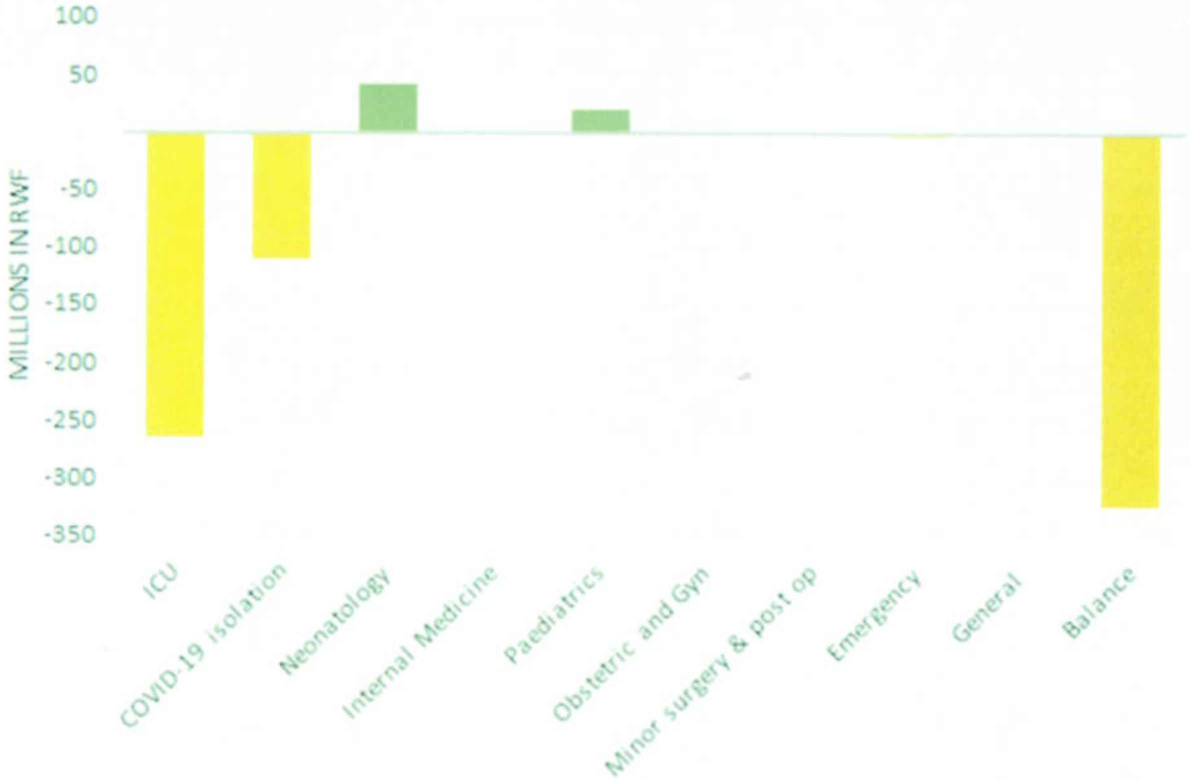
**Oxygen therapy tariffs**

MOH oxygen tariffs are currently set per hour of oxygen therapy (RWF 635 / hour with CBHI), whereas oxygen is purchased by the cubic meter or cylinder. This misalignment creates a lack of predictability as it triggers either losses or gains for the hospitals depending on the types of patients they treat. **An analysis of Patient Electronic Medical Record between June 2019 and June 2020[16], shows that flow rates higher than 4 LPM on patient covered by CBHI pushes service providers into loss**. Specifically, at current market price, an adult ICU patient consuming 11.5 LPM of oxygen will yield a total cost per hour of RWF 1,350. The tariff for CBHI patients is RWF 635/hour, leading to a loss of RWF 715 per patient per hour. On the other hand, with patients requiring lower oxygen flow rates (e.g., neonates and pediatric patients), hospitals typically generate a surplus.

[16] Insurance claims data for 37,809 patients in 25 facilities were analyzed.

Based on updated projections which include a higher proportion of ICU patients receiving oxygen and which take into consideration a surge in COVID-19 patients requiring oxygen at higher flow rates, hospitals could register substantial losses. Figure 7 below shows the financial impact of this scenario for the 25 hospitals for which patient's electronic medical records could be obtained. **These potential losses could turn into a disincentive to use oxygen in all cases requiring it.**

Figure 7 – Potential saving (green bars) and losses (red bars) by ward and in total (million RWF)




What is outstanding to complete this analysis and determine the best course of action is the financial picture for hospitals. The analysis above indicates tariff structure could be major barrier, but evidence also shows hospitals are still buying oxygen and giving it to patients. It is possible that there are additional revenue sources which supplement insurance payments and that currently, the number of low flow patients is high enough to ensure that most hospitals are providing oxygen at a break-even rate or even profit. Providing a clearer picture of the current financial situation can help confirm these which would shift the focus to addressing the potential for creating a bias against administering oxygen to patient's high flow rates and strategies to mitigate the risk of a sustainable situation rapidly deteriorating if the current balance of patients on oxygen changes substantially.

**Maintenance budgets**

Service contracts with private providers to maintain equipment are expensive. For example, CHUK pays RWF 85 million per year for a contract to service the Oxymat oxygen plant, including spare parts. International benchmarks suggest these service contracts could be obtained for a third of the current price. As another point of reference, Ruhengeri spends RWF 24 million per year for a service contract, including spare parts. Further, many hospitals do not have sustainable framework for allocating a maintenance budget, without even a clear sense of whether their oxygen source is profitable. Facilities tend to allocate emergency funds primarily to curative repairs which are absolutely required to treat critical patients or even preferring to refer patients if funds are not readily available, leading to equipment to be used for less time than is possible to generate the maximum amount of oxygen for that facility and the public health system overall.

**Electricity costs**

Hospitals are charged a **non-residential power tariff of RWF 186/kilowatt-hour (VAT excluded)**, while the small-scale industrial customers pay RWF 103/kilowatt-hour (VAT excluded ).[17] This has a significant impact on the costs to run medical oxygen plants and concentrators. Switching to the industrial tariff could save health facilities up to 44% on their electricity bills, which is important given the high electricity consumption of oxygen plants and concentrators. Two hospitals have identified the issue independently and made this switch, benefiting from significant cost reductions, however there is no clear policy or general guidance from RDB in order to ensure all hospitals can leverage this incentive.

**Transportation logistics and costs**

Many oxygen plants are located far from hospitals, leading to high transportation costs of approximately 20-32% as charged by private suppliers. Hospitals in remote areas, particularly the eastern and western regions, report driving up to 4 hours (one-way) to collect oxygen cylinders.

**Visibility on Financial Challenges**

Many financial policies are inadequate or fail to address the issues identified in this section. In general, hospitals have administration over their budget. However, there is no clear mechanism for reporting financial challenges which require shifts in national policy in order to address and no systematic way for national government to identify challenges in a timely manner and address them proactively.

### iii. Functional Equipment and Infrastructure Barriers

There is not enough functional equipment and infrastructure in public hospitals to meet the oxygen therapy demand. Below are the results of an assessment, including results from 29 hospitals in Rwanda.

---

[17] Electricity tariffs, as reviewed by the RURA Board of Directors in its decision N°01/BD/ER-EWS/RURA/2020 are effective from 21st January 2020. Source: https://www.reg.rw/customer-service/tariffs/

| Type of Equipment | Average number of functional equipment per hospital[18] | Percentage of total owned equipment that is functional[18] | Percentage of hospitals that report having enough equipment[19] |
|---|---|---|---|
| Concentrators | 4 | 54% | 41% |
| Cylinders (50L) | 22 | 100% | 48% |
| Cylinders (40L) | 2 | 100% | 55% |
| Cylinders (5L) | 5 | 100% | 69% |
| Cylinders (1L) | 1 | 100% | 90% |
| Cylinders (Other) | 3 | 100% | 76% |
| Pulse oximeters | 5 | 45% | 38% |
| Patient monitors | 8 | 72% | 41% |
| Oxygen analyzers[19] | 0.5 | 85% | 34% |
| Pressure regulators[19] | 9 | 65% | 31% |
| Flowmeters | 15 | 86% | 48% |
| Humidifiers[19] | 11 | 75% | 45% |
| BiPAP & CPAP machines | 1 | 63% | 34% |

**PSA plants** – In Rwanda, 1 out of 17 plants was non-functional in April 2021 (Rwinkwavu hospitals). Causes include the fact that stand-alone maintenance contracts are difficult to manage for PSA suppliers and expensive to sustain for individual facilities. In the absence of coordinated supply partnerships providing affordable maintenance services, hospitals must rely on in-house capacity that often lacks skilled technicians and spare parts supplies. Protracted PSA failures are therefore commonplace.

**Oxygen cylinders** – Almost all hospitals buy supplemental oxygen in cylinders. A recent survey found that there were only 1,510 large type 'J' cylinders available across all facilities. The total number of cylinders in circulation is likely higher as some cylinders were logically outside of the

18 Source: Rwanda biomedical equipment survey, conducted across 69 facilities in September 2020.

19 Source: Medical Oxygen Hospital Assessment Survey, 29 hospitals. *Percentage of hospitals that report having as many pieces of functional equipment required to meet their patient needs.

health facilities at the time of the survey. Assuming that for every cylinder in stock at the health facility, four were either in transit to and from the health facilities and at the refilling station, then the total number of cylinders nationwide should be close to 7,550. The 2021 national quantification exercise estimated that Rwanda needs a total of 18,408 large cylinders to meet projected demand. Each cylinder costs approximately RWF 200,000 therefore requiring an investment of RWF 2.2 billion nationally. In addition, equipment and vehicles for cylinder transport both inside and outside of the hospital are also a challenge.

**Pulse oximeters** – Only 38% of hospitals reported having enough pulse oximeters for $SpO_2$ monitoring[19]. Approximately 45% of pulse oximeters at hospitals are currently not functioning.[18] 10 health centers do not have any pulse oximeters.[18] Low availability of pulse oximeters can be correlated to low oxygen consumption as patients aren't diagnosed.

**Oxygen pipelines** – Many hospitals do not have piped oxygen, which streamlines delivery of oxygen within hospital and can reduce the burden on both clinical and technical staff. A piped supply is especially desirable in hospitals with a high number of patients and/or wards requiring oxygen where reliance on bedside cylinders (e.g., Rwamagana) has proven to be tremendously challenging and cumbersome.

**Oxygen concentrators** – At all three facility levels and COVID-19 treatment centers there were currently 76 10LPM concentrators available – of which only 45 (59%) were functional [18]. Further, the biomedical equipment survey found a large number of non-functional concentrators and a majority of the concentrators found were 5LPM, which are insufficient for use in some patients, particularly in the ICU, emergency and COVID-19 focused wards. The lack of concentrators primarily affects hospitals located more than 30km from the nearest PSA plant, of which there are 19 in Rwanda. In these hospitals, where concentrators are the main source of oxygen, the assessment found that available functional concentrators (of all types) are only able to meet 25% of the estimated need [19]. Failures are reported across all suppliers and brands. In addition, oxygen concentrators require a constant and stable power supply to function properly. However, only 79% of surveyed hospitals report having back up power sources that cover 100% of their needs, and only 38% of hospitals have surge protectors for each of their oxygen concentrators.

**Oxygen analyzers** – Only 5 hospitals reported having any oxygen analyzers available [19]. Oxygen analyzers are essential to ensure safe administration of oxygen therapy when using concentrators (e.g. by confirming purity of oxygen output).

**Other tools for maintenance and analysis** – There are no standardized guidelines for the measurement and analysis of oxygen devices, a standardized list of equipment that should be available and the central medical equipment unit lacks many essential devices for ensuring the quality output of oxygen devices.

**Flowmeters, humidifiers and pressure regulators** – Less than half of surveyed hospitals reported having enough of this equipment to meet patient demand [19].

**BiPAP and CPAP machines** – 43%, or 30 out of 69, surveyed hospitals reported not having a functional BiPAP or CPAP machine [18]. Certain hospitals only have bubble CPAPs that they cannot always operate effectively and safety. Furthermore, only 63% of BiPAP or CPAP devices were functional at the time of the survey [18].

**Spare parts procurement** – 65% of surveyed hospitals reported that spare parts are not always available when needed [19]. Many spare parts are not available on the local market due to limited demand and budget. Therefore, long lead times are required for ordering these spare parts from other countries. Spare parts are expensive due to low volumes (each hospital procures separately) and high transportation costs. In addition, as medical equipment is usually initially purchased at the central level, several hospitals reported that maintenance staff do not know what spare parts to order or where. Further, there is a lack of harmonization of equipment which leads to complications with sourcing spare parts.

**Lack of data on equipment** – There is no central database to verify the status and assist in the management of medical oxygen equipment, which leads to a lack of data for critical decisions such as procurement, allocation, uptime/technical staff management. A Medical Equipment Maintenance Management System (MEMMS) currently being rolled out and could address this barrier in the future.

## vii. Human Resource Barriers

**Maintenance staff** – Hospitals have insufficient capacity for equipment maintenance. Many hospitals do not have biomedical equipment engineers (BMEs), or sufficient biomedical equipment technicians (BMTs) to effectively manage all medical devices, including pulse oximeters, vital signs monitors, oxygen cylinders, central pipelines, or oxygen plants. On average, district, provincial and referral hospitals only have 1-2 trained and certified BMETs who are also responsible for managing at the health centers within the catchment area. 17 of the 69 facilities surveyed reported having no staff at their facility dedicated to the management, installation, and maintenance of medical equipment[18].

**Biomedical engineering trainings** – There is a lack of specialized technical trainings for the following: installation of oxygen cylinders and regulators, oxygen plant maintenance (preventative and curative), production, distribution, oxygen piping, and oxygen concentrators (preventative and curative).

**Clinician trainings** – There is a lack of specialized technical trainings for clinical staff on the management and administration of oxygen therapy. Most clinical staff are trained in school but do not receive continuing education or performance management specific to oxygen. Further, there is a lack of national SOPs, job aids and resources for managing performance which would aid clinical staff interested in applying, renewing or developing this competency.

**Lack of performance management policy** – The current system does not adequately provide information that would assist with the identification and management of human resource barriers. Simple indicators such as the diagnosis of hypoxemia, provision of oxygen therapy and equipment uptime disaggregated by facility and analyzed by key stakeholders would be instrumental in creating timely and targeted solutions and ultimately assuring quality patient care.

# VIII. Implementation Plan

## i. Key Objectives

The overall objective of the strategy is to build on the MOH's many successful initiatives and other experiences, and to provide direction to dramatically improve oxygen availability in health facilities. This requires a comprehensive strategy with a multi-year plan that provides a framework to all the relevant stakeholders and guides the roll-out of oxygen systems nationwide. The key objectives of this national strategy are:

1. Create an enabling policy environment for the management of hypoxemia
2. Increase national oxygen production capacities and implement optimal operating models
3. Improve availability of high-quality diagnostics and oxygen distribution and delivery systems
4. Provide a framework for training of health care workers in health facilities on rational use of oxygen

Scaling up access to medical oxygen is one of the most effective and critical actions that decision-makers can take to improve health outcomes, particularly for vulnerable populations such as newborns, children, and pregnant women. Below are the key strategies for improving access to medical oxygen across public hospitals in Rwanda.

### 1. Create an enabling policy environment for the management of hypoxemia

***Develop standard operating procedures and protocols for oxygen use in health facilities***

Clinical jobs aids for oxygen therapy in hospitals should be developed to guide healthcare providers on how to correctly diagnose hypoxemia and provide the correct medical oxygen therapy.

Standard Operating Procedures (SOPs) should be developed for the management of medical oxygen, to clarify the roles of different departments within hospitals for the management of oxygen supply and to provide clear guidance on key processes such as equipment maintenance, stock management, etc.

In order to ensure the purity and quantity of produced and procured oxygen, SOPs for continuous quality control of oxygen produced at public plants should be drafted, and a certificate of analysis system should be developed to guarantee the quality of oxygen procured from private suppliers.

For oxygen plants procurement, national technical specifications must be developed to ensure quality and adequacy of procured plants (as for all medical equipment). Then, supplier pre-qualification should be developed in the procurement process, in order to increase the standardization of equipment. Limiting the number of approved suppliers could improve quality of equipment and simplify equipment management.

In addition, essential oxygen therapy equipment lists should be refined for each health facility level, clearly indicating minimum type and quantity of each piece of equipment (pulse oximeters, vital signs monitors, oxygen analyzers, flowmeters, humidifiers and pressure regulators, CPAP machines, etc.).

***Create coordinating mechanisms for oxygen scale-up at national and state level***

A national coordination mechanism for oxygen scale-up, led by the MOH and RBC, will be established to ensure effective implementation of the national strategy. One of the key tasks of the coordinating committee will be to keep track of the financial commitments towards the total oxygen strategy budget, and to inform the resource mobilization strategy.

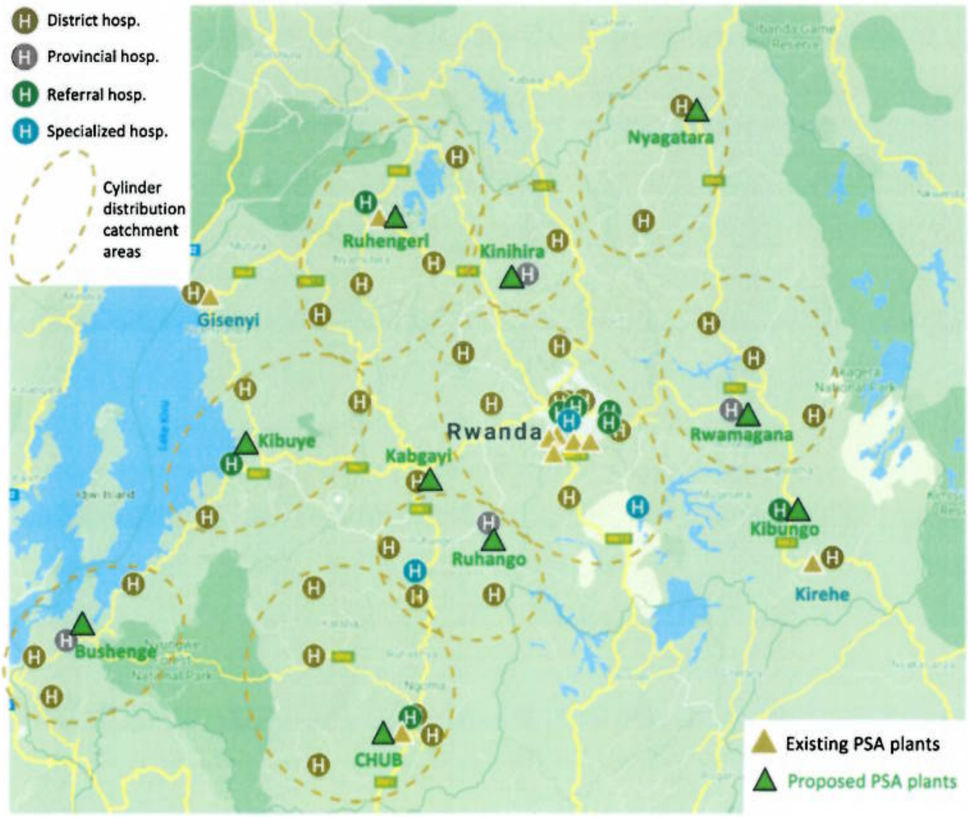
## 2. Increase national oxygen production capacities and implement optimal operating models

***Select and implement optimal oxygen production and distribution models***

Given available technologies and Rwanda's current oxygen landscape, notably the absence of a local liquid oxygen plant, the most cost-effective model to scale up oxygen production is a network of decentralized PSA plants coupled with a cylinder distribution system to lower-level hospitals. Because portable concentrators have a shorter lifespan compared with larger PSA generators and require an extensive repair and maintenance platform, these devices should only be used in a limited number of health facilities that would be too expensive to serve or are hard to reach with cylinders.

To bridge the current supply gap, this strategy calls for installing 11 new PSA plants in strategic locations (see map 1 below) and establishing a hub-and-spoke model for cylinder distribution (see Appendix 2). The proposed locations of new PSA plants are meant to ensure equitable geographical access to oxygen while minimizing distances between the lower-level hospitals receiving cylinders and PSA plants to keep distribution costs low.

Map 1 – Proposed PSA plant locations & cylinder delivery catchment area




Based on the calculated demand for oxygen and geographic access to oxygen supply sources, at least one hospital in each province should have a high-capacity oxygen plant installed. In the case of CHUB, the next step is to increase the capacity of the current plant by adding one or several PSA generators to meet the whole need in the catchment area. These hospitals were selected based on the demand for oxygen in their province (see table 5), their location/accessibility for other hospitals in the province, the age and current utilization rates of their existing plants, and their readiness to host a plant.

Table 5 – Estimated oxygen need in $m^3$ per hours of the 'hub' hospitals and their respective catchment areas

| Health Facility Name | Nbr of HF to serve in the catch. Area | Total need to serve in catch area (m3 / hr) BASE CASE | Max. Instant O2 need (m3/hr) of the host hospital BASE CASE |
|---|---|---|---|
| KINIHIRA | 2 | 17 | 18 |
| KABGAYI | 2 | 21 | 30 |
| NYAGATARE | 3 | 53 | 49 |
| BUSHENGE | 4 | 56 | 26 |
| RUHANGO | 5 | 59 | 27 |
| RWAMAGANA | 4 | 44 | 31 |
| CHUB | 6 | 52 | 46 |
| KIBUNGO | 1 | 16 | 33 |
| KIBUYE | 4 | 42 | 34 |
| RUHENGERI | 4 | 59 | 36 |
| Nyarugenge | 1 | 51 | 81 |

Source: RBC/CHAI oxygen quantification exercise, Nov 2020-Feb 2021

Existing plants that are not functional or are operating below their maximum capacities should be assessed by a biomedical engineering team, repaired and integrated into the above-mentioned hub-and-spoke cylinder distribution model.

Priority for hosting oxygen plant should be given to hospitals that have existing piping. This ensures that patients requiring emergency oxygen, especially in the context of COVID-19, can be treated within hospitals that have piping. As future investments are secured to develop piping networks in additional facilities oxygen supply should be distributed to the additional facilities based on ongoing oxygen needs.

***Establish a Public Private Partnership (PPP) for oxygen***

On-site oxygen PSA plants require regular maintenance to ensure uninterrupted oxygen supplies and to maximize the equipment's productive lifespan. In addition, biomedical engineers, technicians, and cylinder handlers should be continuously present at the production site to operate the plant. Models that bundle plant operation, maintenance and cylinder distribution services into long-term supply contracts are, therefore, ideal.

This bundled model can be implemented through three broad options:

**1 Public option**

- **Description:** public hospitals (or another public entity) procure, own, operate the PSA plants + handle cylinder deliveries to lower level health facilities.
- **Pros**
  - Cylinder sales generate an additional stream of income for hospitals
  - Immediate ownership of the asset by the Government
  - Technical capacities built within the public sector
- **Cons**
  - High capital expenditure has to be entirely borne by the Government
  - Higher risk of equipment downtime and supply chain failure *
  - Complex repair & maintenance and cylinder supply chain has to be organized by each hospital or streamlined into a central platform with adequate resources
- **Examples:** CHUB, CHUK and King Faisal Hospital

**2 Private option**

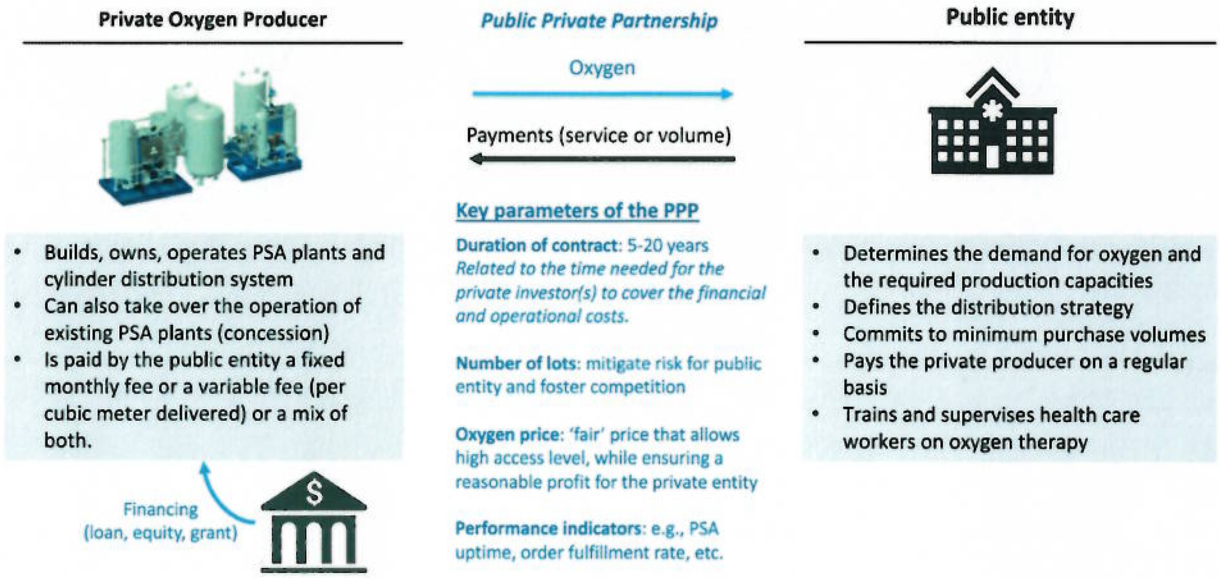
- **Description:** hospitals purchase oxygen from existing private oxygen producers using simple cash-and-carry arrangements or supply framework contracts.
- **Pros**
  - Flexible arrangements that can be easily started and terminated
- **Cons**
  - Fragmented & unpredictable demand from multiple health facilities drives oxygen prices up
  - Lack of long term visibility over oxygen demand + high non-payment risk deter private companies from making the required large scale investments to increase production capacities
  - Higher risk of non-compliance with quality standards for oxygen production & distribution.
  - Ownership of the PSA plants remains with the private companies
- **Examples:** most district and provincial hospitals that do not have a PSA plant.

**3 Public Private Partnership (PPP) option**

- **Description:** Government and one or several companies enter into a long-term agreement whereby the private companies own and operate PSA plants, and supply O2 to hospitals at set conditions (e.g. price).
- **Pros**
  - 'Oxygen as a service' = hospitals buy oxygen and do not have to worry about repair, maintenance, distribution
  - No increase in public debt
  - Demand predictability lowers risk & makes prices more affordable
  - Production capacity expansion is financed by the private sector
  - Ownership of the plant transferred to the public sector at the end of the PPP
- **Cons**
  - Commits the public sector to buying certain minimal quantities per year
  - PPP can be complex to negotiate and manage and require adequate monitoring capacities.
- **Examples:** AWB and Gisenyi Hospital under a Build-Operate-Transfer arrangement

This strategy recommends establishing an oxygen Public Private Partnership as described below on diagram 2 to minimize public capital expenditure, and leverage the expertise of private sector companies in the field of PSA plant installation, maintenance and operation. Thanks to its robust PPP regulation, and the high coverage of Rwanda Social Security Board's (RSSB) Community Based Health Insurance which makes most of the national oxygen demand solvent, Rwanda is well-positioned to establish a successful PPP.

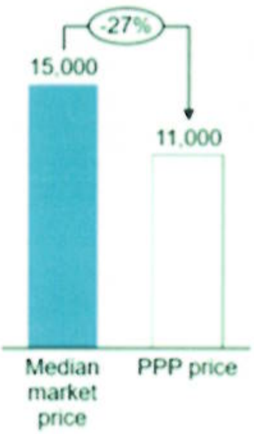
Diagram 2 – Simplified Build-Operate-Transfer PPP model for oxygen




Existing PPPs in Sub-Saharan Africa have demonstrated their potential to expand access to oxygen. In Kenya, a PPP between several county governments and the social enterprise Hewa Tele operates three PSA plants and serves hospitals within a two-hour drive from the nearest plant. In Rwanda, a PPP between AWB and Gisenyi Hospital under a 10-year Build-Operate-Transfer arrangement operates a 37 $m^3$/hour PSA plant and serves nearby hospitals.

As shown in Figure 8 below, an oxygen PPP, if well-structured and negotiated, has the potential to substantially improve affordability of oxygen in Rwanda. The price could even drop further in case the private companies manage to secure concessional loans and/or grant funding to lower their cost of capital, or if they benefit from government-implemented incentives such as lower electricity tariffs and tax exemptions.

Figure 8 – Potential price reduction through an oxygen PPP (RWF per large "J" size cylinder)




**Methodology:**

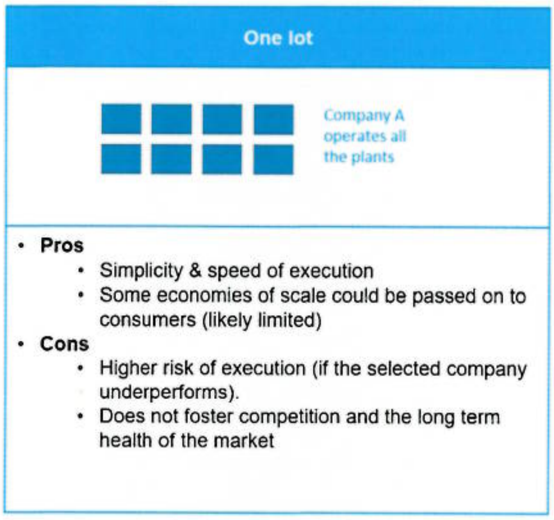
To determine an optimal PPP selling price, the cash flows of a private company entering into a long-term agreement with the Government of Rwanda was modeled over a 10-year period. The Net Present Value (NPV) was used as an indicator of overall business profitability.[20] The PPP price is defined as the lowest selling price that allows the project to yield a positive NPV.[21]

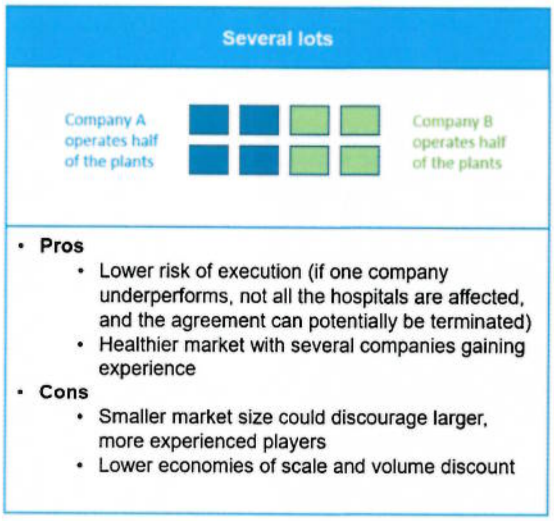
**Key assumptions:**

Capital expenditure: fully fledged PSA plants incl. cylinder filling station, cylinders, back-up generator, delivery truck (Total ~US$ 4 M for 5 plants). Asset financing: 75% commercial debt @ 17% interest p.a. over 5 years & 25% equity shares @ 10% shareholder returns. Land provided at no cost by the health facility. Revenues: progressive customer acquisition over the first 5 years of operations. Operating costs: electricity, repair & maintenance, transportation, staff costs. Taxation: 30% corporate income tax.

Importantly, the oxygen volume required to make the PPP economically viable can only be achieved if the demand for oxygen is aggregated across multiple hospitals in each catchment area and at national level. Practically, hospitals should be contractually obliged to buy oxygen from the PPP at the agreed-upon prices.[22] Additionally, the Government of Rwanda will stand as a 'payer of last resort' to protect the private companies involved in the PPP against hospital non-payment risks, and thus allow these companies to offer lower oxygen prices.

Splitting the PPP into multiple lots is a good way to encourage the long-term health of the oxygen market in Rwanda and in the region and lower risk for the government. Given the relatively low overall market size, splitting the PPP into more than two lots is not advisable.




Finally, several public entities could play the role of contracting authority in the PPP (summarized below). The key criterias to decide on the contracting authority are the technical expertise and the monitoring capacity.

---

[20] Cash flow annual discount rate = 15% (the weighted average cost of capital in the base financing scenario).

[21] Sensitivity analyzes were run to test the robustness of the financial projections using energy costs and financing costs as variables. The price range that allows the project to yield a positive NPV under most scenarios was RWF 10,000 - 12,000.

[22] Exemptions to this rule will be provided for such as breakdown at the PPP plant and inability to fulfill order.

**Rwanda Biomedical Center (RBC)**

- Established in 2011 through a merger of fourteen key health institutions.
- Mandate: RBC is the nation's central health implementation agency.
- Medical Procurement and Production Division (MPPD) within RBC has historically played the role of coordinating the regional pharmacies but this role has recently been transferred to RMS.

**Rwanda Medical Supply (RMS)**

- Created as an independent entity by an act of parliament in 2019
- Mandate: to ensure availability of quality and affordable pharmaceutical products, medical equipment and consumables to the population of Rwanda
- Rwanda Medical Supply Limited is a corporation created and owned by the Government of Rwanda

**Ministry of Health**

- Mandate: policy & strategy development, regulations,
- Monitoring and evaluating

**Rwanda Social Security Board (RSSB)**

- Mandate: Provide high quality social security services, ensure efficient collection of contribution, benefits provision, management and prudent investment of members' funds

## 3. Improve availability of high-quality diagnostics and oxygen distribution and delivery systems

***Intra-hospital distribution infrastructure and equipment (piping, cylinders)***

Once it is produced, oxygen can either be stored in high-pressure cylinders and distributed, or directly piped to the patient bedside. Because most hospitals in Rwanda are made of several one- or two-story buildings located far from each other, installing a single interconnected medical gas pipe network can be impractical and expensive. Several pipe networks, one per ward, each equipped with its own manifold system connected to cylinders, can be a more adequate option (see diagram 3).

Diagram 3 – Manifold system & oxygen piping in a hospital ward

*Oxygen piping in a hospital ward*

*Manifold system outside of the ward*

To increase patients' and health care workers' safety and reduce oxygen leakages, **all national and provincial hospital should build comprehensive oxygen piping networks covering all in-patient wards. Critical wards (ICU, surgery, emergency) should be piped as a matter of priority, followed by maternal, pediatric and neonatal ward.** Piping for other medical gases and vacuum should be added when needed. District hospitals should then be pipped.

Every bed receiving a hypoxemic patient should be equipped with a full set of Thorpe-tube flowmeters, pressure regulators and humidifiers

***Respiratory care equipment***

In ICU, surgery and emergency settings as well as COVID-19 critical cases (usually integrated in patient monitors), **pulse oximeters** play a critical role in guiding non-invasive ventilation and mechanical ventilation procedures. Facilities should have one tabletop pulse oximeter per ICU bed and operating theater, and one handheld pulse oximeter per bed excluding ICU beds.

Facilities need to ensure they have the correct amount of **CPAP machines** for all types of patients – adults, children, and neonates - when other non-invasive mechanical ventilation methods are inefficient to correct the oxygen saturation. For adult CPAPs, hospitals should have one machine for every two ICU beds. Pediatric wards should have one pediatric CPAP machine for every 10 pediatric beds, and neonatal units should have two neonatal CPAP machines for every 10 neonatal beds.

Hospitals should have **one ventilator** for every ICU bed.

High-flow nasal oxygen (HFNO) is delivered by an air/oxygen blender, an active humidifier, a single heated circuit, and a nasal interface called High Flow Nasal Cannula (HFNC) to deliver adequately heated and humidified oxygen at high flow rates up to 60L/min.

Table 6 summarizes the current need in Rwanda across all facilities for each of these pieces of equipment, along with the basis for its recommendation.

Table 6 – Need and currently available equipment across all facilities

| **Equipment** | **Currently available** | **Need** | **Basis for recommendation** |
|---|---|---|---|
| Tabletop pulse oximeters | 38 | 443 | 1 per ICU bed and operating theater |
| Handheld pulse oximeters | 176 | 439 | 1 per bed excluding ICU and operating theater |
| Fingertip pulse oximeters | 130 | 93 | |
| Adult CPAP | 8 | 169 | 1 CPAP per 2 ICU beds |
| Pediatric CPAP | 4 | 127 | 1 CPAP per 10 pediatric beds |
| Neonatal CPAP | 84 | 149 | 2 CPAP per 10 neonatal beds |
| Ventilators | 93 | 337 | 1 ventilator per ICU bed |

Source: National oxygen gap assessment, May 2020

***Plant maintenance***

Oxygen plant maintenance contracts should be revised to decrease overall costs. Rather than procuring comprehensive maintenance contracts, BMEs should be adequately trained on first and second lines of support and contract scope could be reduced to cover only the third, fourth and fifth lines of support. This must be done through a phased approach – BME capacity should be verified prior to ending any maintenance service contracts with private providers.

A portion of hospital budgets should be allocated to the maintenance of medical oxygen equipment and infrastructure (to be defined in the national strategic plan for health equipment and infrastructure).

***Equipment procurement, inventory control and asset management, maintenance management, data management***

Equipment acquisition and distribution should be taken into account early in the medical oxygen equipment budgeting and procurement process – at time of purchase of the initial piece of equipment. Guidelines for quantifying equipment according to oxygen consumption and clinical need as well as functional and operation requirements should be defined by the Ministry of Health with input from MTD, hospital management and relevant professional associations. Bundling or procuring all key consumables and spares needed for a reasonable period of use, defined by the equipment's lifespan and length of procurement cycle, at the same time as the initial equipment purchase can improve availability of spares and consumables, and decrease unit costs. Centralizing procurement management (e.g., under Rwanda Medical Supply (RMS)) for key commodities and spare parts could lead to faster procurement times and lower costs, and ultimately improve the availability of functional medical oxygen equipment in hospitals. Initially, this could be done for broadly standardized or interchangeable spare parts, such as vital signs monitor probes and medical oxygen plant spare parts. Stock keeping for any key SKUs like critical spare parts is also recommended to facilitate rapid equipment maintenance and avoid down-times due to long procurement processes. In addition, local distributors can be encouraged to invest in key commodities to increase the local availability of spare parts by making projected volumes required by public health facilities more transparent in the form of an aggregated forecast or call-down contracts based on expected multi-year need for spare parts that specify maximum delivery timelines (and which would therefore incentivize stock keeping for the specified SKUs).

Technical requirements for medical oxygen plants should be reviewed and standardized for optimal procurement as well as ease of sourcing of spare parts and trainings for BMEs – this will require technical specifications development and pre-qualification of suppliers, as stated in the previous section.

All equipment goes through a basic lifecycle: procurement, allocation and distribution, preventative maintenance, repair or swapping, re-allocation, salvage, and disposal. There are two primary tasks carried out as part of equipment management that track equipment through this lifecycle – equipment control and asset management, and equipment maintenance management. The objective of equipment control and asset management is to develop a rational system for allocating, re-allocating, salvaging, and disposing of equipment. It ensures equitable access to equipment and enables agile equipment allocation and replacement as contexts change. The equipment maintenance management system should be responsible for carrying out routine tests, calibration, and other preventative maintenance to ensure continued patient access to functional equipment.

A good data management system is the driver for performance management. It enables hospitals to quickly identify challenges, address them as part of continuous learning, and work to ensure continued quality assurance. Data elements related to both equipment control and asset management and equipment maintenance management should be stored in MEMMS. Data should be available to management, administration, engineers, technicians and clinicians with the level of detail dictated by what action is expected of each audience. Data quality should be tracked on a routine basis by each facility and should be regularly analyzed to ensure quality assurance. As such, BME/Ts can utilize captured data to ensure that medical equipment meets performance and operational criteria, optimize device uptime to meet patient needs, and reduce the risk to staff and patients of injury or death.

In addition to core processes, it is critical for the regulation, quality assurance of management processes and quality control of products, tools and commodities to be considered. A quality system ensures the equipment being used for oxygen delivery is safe and suitable for patients. It is comprised of administrative and procedural activities that ensure requirements are met for all pieces of oxygen equipment through systematic measurement, comparison with a standard, monitoring of processes and an associated feedback loop that confers error prevention. In Rwanda, policy, strategy, and clinical guidelines and regulations should fall under the MOH while the Rwandan FDA should oversee quality assurance processes. This includes the development of or revision of strategies, guidelines and regulation that governs the production, import, distribution and use of oxygen, including but not limited to

- Relevant program strategies, such as MNCH
- Clinical guidelines
- National equipment list and procurement guidelines
- Essential medicines list
- National pharmacopeia
- Applicable import duties & taxes
- Quality Assurance
- Health Facility Standards & Processes
- Including equipment list, budgets, SOPs for inventory control and asset management and maintenance management

### *BME/BMET capacity*

In order to maximize the lifespan of durable equipment, it is very important to build the capacity of biomedical engineers and technicians (BME/Ts) in health facilities. BME/Ts play a number of roles in equipment procurement and maintenance including contributing to equipment selection and installation, ensuring the equipment used for diagnosis and treatment is safe for patients, investigating equipment failures, and assisting in the development and maintenance of data and asset management systems.

Every facility should either have a biomedical engineer or technician on staff or have access to a biomedical technician or engineer on a timely basis to support with repair and maintenance. In facilities without technicians or engineers, clinical staff can be trained in basic preventive maintenance and understanding how and when to engage technicians and engineers for support. This training and support can be provided from the Medical Technology Division (MTD) directly, a regional support model or a mobile Centre of Excellence. Manuals and protocols on the use and maintenance of oxygen equipment should be available within facilities, including those unique to products. Operations and maintenance contracts should be secured with suppliers at the time of equipment purchase to ensure proper maintenance and upkeep of equipment.

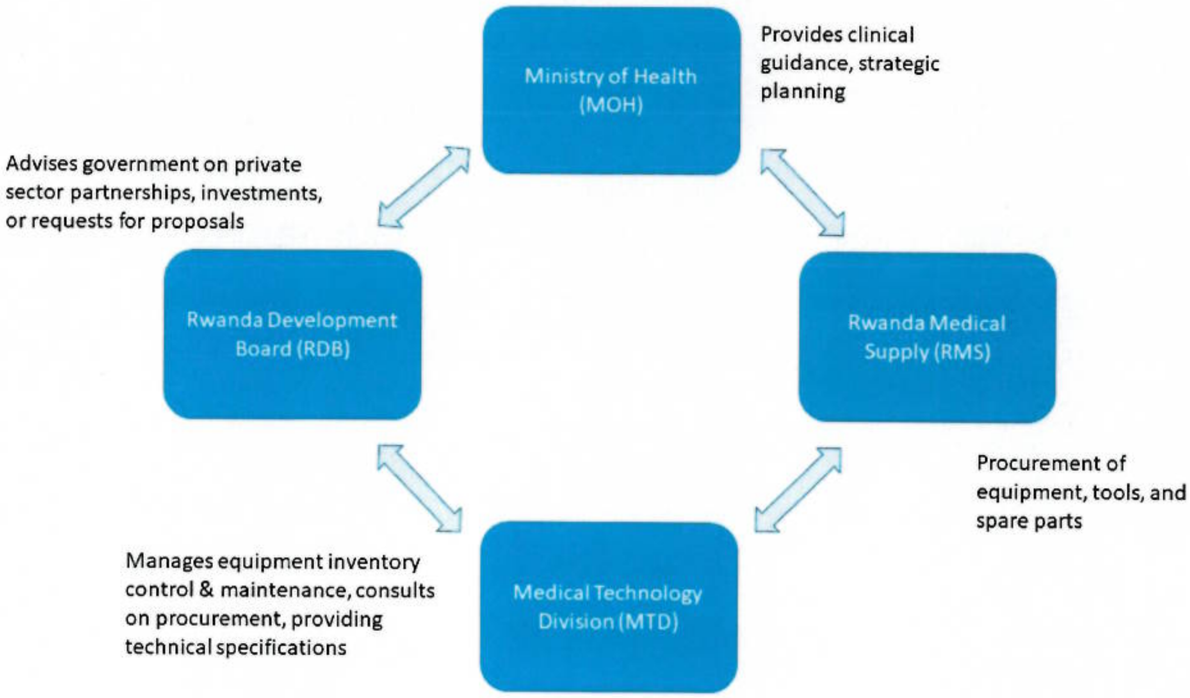
Recommended actions:

- Capacity building to use oxygen equipment correctly to diagnose hypoxemia and provide oxygen therapy;
- Maximizing the oxygen equipment uptime by establishing an enabling environment for preventive maintenance and repair
- Establish a monitoring mechanism to provide on the job training and performance management

### *Roles and Responsibilities*

Equipment management requires coordination between numerous stakeholders, including the Rwandan Development Board (RDB), the MOH, the Rwandan Medical Supply (RMS), and the Medical Technology Division (MTD). Their roles and responsibilities are outlined below in Figure 9. At present, the MTD has capacity to provide advanced mechanical, electromechanical, and curative maintenance support, along with management of data including inventory. Rwanda can further develop the capability of technicians using MTD capacity by establishing Centers of Excellence – units with the ability to conduct specialized support, mentoring, and educational support activities and that can operate as connectors between national and facility levels.

Figure 9 - Stakeholder roles in equipment inventory control




Roles and responsibilities should be defined as follows:

- The MTD should draft guidance and lead on the overall planning for procurement activities. They will provide specialized support with hands-on mentoring to conduct repair and preventive maintenance, provide guidance and develop policies and processes for the proper work order management and quality assurance of equipment installation and management, provide oversight to data systems whose scope includes respiratory care equipment, advise on the procurement of equipment and spare parts, and continue to define best in class equipment management using continuous monitoring, learning and evaluation.

- Facilities have a narrower scope, focusing on defining and executing a budget for repairs, replacement of spare parts and preventive maintenance, while reporting needs for assistance and quantities required for centrally organized procurements as required to MTD.

- Centers of Excellence should be established and act as hubs for more specialized tools, equipment to swap when critical equipment is down, and other products which make sense to have access to regionally. In addition, they can provide specialized support, mentoring, and educational activities to build the capacity of facility technicians.

- RMS is responsible for the procurement of any equipment, tools and spare parts which are not directly procured by facilities, subject to input from all relevant stakeholders including but not limited to MTD, MOH and hospital administration.

- MOH should provide clinical guidance and strategic planning for the use of medical equipment, clinical flow, technical and operational requirements of equipment.

- RDB should be engaged on any private sector partnerships, investments or tendering processes.

### 4. Provide a framework for training of health care workers in health facilities on rational use of oxygen

Clinician training modules and checklists should be developed to ensure clinician staff know how to appropriately provide quality medical oxygen therapy to patients, including screening and diagnosing hypoxemia, proper administration of medical oxygen, knowing when oxygen therapy has been adequate and weaning patients from oxygen. These elements should also be included in pre-service training for nurses, midwives, health officers and doctors where it isn't currently the case.

Patients should be sensitized by clinicians on the importance of oxygen therapy and how to properly receive it.

Local suppliers in partnership with manufacturers should be required to deliver specialized first-level trainings to medical oxygen equipment end users and maintenance staff for appropriate medical equipment management, including operation and preventative and curative maintenance. This requirement should be systematically included in tenders and enforced by receiving hospital management upon equipment commissioning.

Finally, advanced trainings should be provided to at least 2-3 biomedical engineers for each brand of oxygen plant, and he/she could then train other engineers. We can leverage existing specialized skillsets available in the country (e.g., KFH BMEs who already have advanced training on Oxymat plants could train other facilities on that brand).

Mandatory continuing education, in the form of refresher training modules (potentially online) for medical oxygen equipment maintenance and repair, should be developed to build capacity of biomedical engineers and/or technicians. These trainings will be aligned with the training program set out in the national strategic plan for health equipment and infrastructure.

Whenever possible, these trainings should be included in broader biomedical and end-user trainings on medical equipment in hospitals.

Trainings should be evidence based, practical focused and leverage consistent testing practice in order to maximize learning and applicability.

## IX. Investment Case and Financing

Large-scale, coordinated investments in national oxygen systems are required to expand production and distribution capacities. No country has built a system that guarantees access to reliable, high-quality medical oxygen without substantial public-sector investment. At the same time, private capital can play a synergetic role and bring much-needed expertise in installing, operating and maintaining oxygen production units. As part of the Covid-19 response, social impact investors and Development Finance Institutions (DFIs) have been increasingly active in the medical oxygen space.

This section outlines the main cost components underpinning this road map and various avenues to finance both capital and operating expenditure over the long run.

### a. Preliminary oxygen strategy costing

The costing data presented in this section are preliminary. They include first the upfront investment cost (i.e., capital expenditure, or 'CAPEX') required to increase the production and distribution capacities, as well as an estimation of the annual operating expenditure ('OPEX').

***Upfront investment costs***
According to the strategy, 11 fully functional PSA plants, including oxygen pipe systems (when needed) are required to equitably expand oxygen access in Rwanda. When possible, duplex PSA plants are proposed (instead of a large single plant) since they offer more flexibility and supply security.[23]

The corresponding costs are summarized in table 7. Costing is based on average ex-works unit costs plus shipping, handling, distribution, and installation costs. **Total upfront investment costs for 11 new PSA plants plus the delivery trucks and cylinders are estimated at US$ 6.7 million** (excluding piping which is costed separately below).

Table 7 – Detailed upfront investment costs by hub hospital, excluding oxygen piping (US$)[24]

[23] For instance, when one plant needs to be serviced, the other can remain functional so that the oxygen supply is not interrupted.

[24] The total in the 'hospital piping network' column does include all 51 health facilities where piping work is to be performed, which explains why it does not equal the sum of the lines.

| Health Facility Name | PSA plant | Cylinder refilling station | Back-up generator | Contenarized plant ("plug & play") | Construction work (plant building, power connection) | Delivery truck | Cylinders | TOTAL CAPEX |
|---|---|---|---|---|---|---|---|---|
| KINIHIRA | $ 58 500 | $ 65 000 | $ 15 000 | $ 30 000 | $ 5 000 | $ 55 000 | $ 109 940 | **$ 338 440** |
| KABGAYI | $ 117 000 | $ 130 000 | $ 25 000 | $ 30 000 | $ 5 000 | $ 55 000 | $ 120 060 | **$ 482 060** |
| NYAGATARE | $ 171 600 | $ 156 000 | $ 35 000 | $ - | $ 10 000 | $ 55 000 | $ 188 370 | **$ 615 970** |
| BUSHENGE | $ 171 600 | $ 156 000 | $ 35 000 | $ - | $ 10 000 | $ 55 000 | $ 478 170 | **$ 905 770** |
| RUHANGO | $ 171 600 | $ 156 000 | $ 35 000 | $ - | $ 10 000 | $ 55 000 | $ 392 380 | **$ 819 980** |
| RWAMAGANA | $ 144 300 | $ 143 000 | $ 35 000 | $ - | $ 10 000 | $ 55 000 | $ 282 900 | **$ 670 200** |
| CHUB | $ 104 000 | $ 91 000 | $ 35 000 | $ - | $ 10 000 | $ 55 000 | $ 365 010 | **$ 660 010** |
| KIBUNGO | $ 117 000 | $ 130 000 | $ 25 000 | $ 30 000 | $ 5 000 | $ 55 000 | $ 45 310 | **$ 407 310** |
| KIBUYE | $ 117 000 | $ 130 000 | $ 25 000 | $ 30 000 | $ 5 000 | $ 55 000 | $ 266 570 | **$ 628 570** |
| RUHENGERI | $ 85 800 | $ 78 000 | $ 25 000 | $ 30 000 | $ 5 000 | $ 55 000 | $ 366 160 | **$ 644 960** |
| Nyarugenge | $ 171 600 | $ 156 000 | $ 35 000 | $ 30 000 | $ 5 000 | $ - | $ 133 860 | **$ 531 460** |
| TOTAL | **$ 1 430 000** | **$ 1 391 000** | **$ 325 000** | **$ 180 000** | **$ 80 000** | **$ 550 000** | **$ 2 748 730** | **$ 6 704 730** |

The cost variation between the different hub hospitals can be explained by differences in oxygen need, size of the catchment area, and current readiness (e.g., presence of an existing PSA plant).

Table 8 shows the number of units of each main equipment piece for each hub hospital. The number of "J" size cylinders required was calculated assuming a 4-day buffer stock of cylinder at the hub hospital to ensure supply security in case production stops and a weekly delivery of refilled cylinders to the surrounding district hospitals.

Table 8 - Number of units of each major equipment piece per hub hospital[25]

| Health Facility Name | Small PSA (12-19 Nm3/hr) | Medium PSA (20-27 Nm3/hr) | Large PSA (28-35) Nm3/hr) | Back-up generator (Small) | Back-up generator (Medium) | Back-up generator (Large) | Contenarized ("plug & play") | Construction: Light civil engineering work | Construction: Entire building + electricity | Cylinder refilling station (Small) | Cylinder refilling station (Medium) | Cylinder refilling station (Large) | Delivery truck | Cylinders (net need) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| KINIHIRA | 1 | | | 1 | | | 1 | 1 | | 1 | | | 1 | 478 |
| KABGAYI | 2 | | | | 1 | | 1 | 1 | | 2 | | | 1 | 522 |
| NYAGATARE | | 2 | | | | 1 | | | 1 | | 2 | | 1 | 819 |
| BUSHENGE | | 2 | | | | 1 | | | 1 | | 2 | | 1 | 2079 |
| RUHANGO | | 2 | | | | 1 | | | 1 | | 2 | | 1 | 1706 |
| RWAMAGANA | 1 | 1 | | | | 1 | | | 1 | 1 | 1 | | 1 | 1230 |
| CHUB | | | 1 | | | 1 | | | 1 | | | 1 | 1 | 1587 |
| KIBUNGO | 2 | | | | 1 | | 1 | 1 | | 2 | | | 1 | 197 |
| KIBUYE | 2 | | | | 1 | | 1 | 1 | | 2 | | | 1 | 1159 |
| RUHENGERI | | 1 | | | 1 | | 1 | 1 | | | 1 | | 1 | 1592 |
| Nyarugenge | | 2 | | | | 1 | 1 | 1 | | | 2 | | | 582 |
| TOTAL | 8 | 10 | 1 | 1 | 4 | 6 | 6 | 6 | 5 | 8 | 10 | 1 | 10 | 11 951 |

Of note: Nyarugenge hospital has been designated as a priority facility to admit COVID patients, especially critical ones. This has substantially increased its oxygen need and justify the installation of a dedicated plant. Contrary to the other proposed PSA plants, the plant in Nyarugenge is solely meant to meet the need of that hospital (no hub-and-spoke model).

As discussed in the previous sections, piped oxygen is the most efficient way to deliver oxygen in a hospital setting, particularly to adult patients with critical illnesses. The number of relevant beds that would benefit from being connected to an oxygen piping network in every hospital was

[25] Only hub hospitals are shown in this table. Oxygen pipe network will also be installed at district hospitals (not shown here but calculated in the total investment cost).

computed.[26] As shown in table 9 below, the bulk of the beds left to be connected are located at the district hospitals level.

Table 9 – Breakdown of relevant beds not connected to oxygen piping as of April 2021

| | # of hospital without piping | # beds to connect |
|---|---|---|
| District hospital | 24 | 3 772 |
| Provincial hospital | 1 | 255 |
| Referral hospital | 2 | 423 |
| **Total** | **27** | **4 450** |

Source: RBC (2021), BME assessment (2020)

As shown on table 10, **installing oxygen piping networks in all district, provincial and referral hospitals represents a significant investment, totaling US$ 8 million**. Given that referral and provincial hospitals are, to a large extend, already piped, the cost at this level remains relatively limited (total = US$ 1.2 million). On the contrary, very few district hospitals have piping. As a result, the cost of installing piping to the 24 remaining hospitals (and expanding the reach of piping systems in some district hospitals) is estimated at close to US$ 7 million.

Table 10 – Number of beds to connect and cost oxygen piping installation by hospital level[27]

| | # of hospital without piping | # beds to connect | Estimated costs | |
|---|---|---|---|---|
| District hospital | 24 | 3 772 | $ | 6 790 052 |
| Provincial hospital | 1 | 255 | $ | 459 252 |
| Referral hospital | 2 | 423 | $ | 761 221 |
| **Total** | **27** | **4 450** | **$** | **8 010 526** |

**In summary, the total capital expenditure required to scale up oxygen according to this strategy amounts to nearly US$ 15 million**. Importantly, this CAPEX figure does not include the cost of procuring additional respiratory care equipment (e.g., ventilators, CPAP/BiPAP machines, pulse oximeters).

This health infrastructure investment has the potential to last 15 years (and much more in the case of oxygen piping), if well maintained, and can deliver substantial health benefits across a large spectrum of diseases and age groups.

---

[26] In every hospital, the total number of beds requiring piped oxygen was calculated using latest bed capacity data in the following in-patient wards (neonatal, pediatric, ICU, operating theater, emergency room and COVID). Beds that are known to be already connected to an oxygen piping system were deducted from the count (source: Rwandan Biomedical Center, 2021).

27 These costs figures are preliminary. Calculating the cost of installing oxygen piping can only be accurately performed by a specialized engineering team after having assessed each hospital's configuration, layout and need. The costing presented on this table assumes the average cost of connecting one bed is US$ 1,800.

***Annual operating costs***

An often-neglected aspect when deciding to procure PSA plants is the recurring operating costs. Oxygen production is very energy-intensive, and as such the main cost driver when operating a PSA plant is electricity. Besides electricity, skilled engineers, technicians, as well as semi-skilled operators such as workers handling the cylinders and drivers, must be hired and trained to run the plants. Repair & maintenance costs, including spare parts, must also be budgeted. Finally, the cost of distributing the cylinders regularly should be taken into consideration. Most of these costs are variable depending on the plant's utilization.

**Estimated annual operating expenditures (OPEX) for hub hospitals amount to US$ 2.3 million** for 11 PSA plants, mainly driven by electricity cost[28] (~70% of total OPEX). Table 11 shows the detail by hub hospital. As electricity is a significant portion of the costs associated with oxygen production, the Ministry of Health should advocate to the Rwanda Energy Group (REG) for a reduction of the cost of electricity per KWh. Aligning the cost per KWh with the medium-size industrial customer rate (RWF 103 + 18% VAT) would reduce the PSA generation energy bill by 44% and generate savings of about US$ 700,000 per year at the national level.

Table 11 - Annual operating cost by hub hospital (US$)

| Health Facility Name | Facility_type | Annual staff cost | Annual Maintenance | Training (one-off) | Power (assuming run time of 18h / day | OPEX for hub hospitals |
|---|---|---|---|---|---|---|
| KINIHIRA | Provincial Hospital | $ 19 500 | $ 16 000 | $ 5 850 | $ 60 328 | **$ 101 678** |
| KABGAYI | District Hospital | $ 19 500 | $ 16 000 | $ 11 700 | $ 120 656 | **$ 167 856** |
| NYAGATARE | District Hospital | $ 21 900 | $ 31 500 | $ 17 160 | $ 193 049 | **$ 263 609** |
| BUSHENGE | Provincial Hospital | $ 21 900 | $ 31 500 | $ 17 160 | $ 193 049 | **$ 263 609** |
| RUHANGO | Provincial Hospital | $ 21 900 | $ 31 500 | $ 17 160 | $ 193 049 | **$ 263 609** |
| RWAMAGANA | Provincial Hospital | $ 21 900 | $ 31 500 | $ 14 430 | $ 156 853 | **$ 224 683** |
| CHUB | Referral Hospital | $ 28 200 | $ 42 000 | $ 10 400 | $ 128 699 | **$ 209 299** |
| KIBUNGO | Referral Hospital | $ 19 500 | $ 16 000 | $ 11 700 | $ 120 656 | **$ 167 856** |
| KIBUYE | Referral Hospital | $ 19 500 | $ 16 000 | $ 11 700 | $ 120 656 | **$ 167 856** |
| RUHENGERI | Referral Hospital | $ 21 900 | $ 31 500 | $ 8 580 | $ 96 525 | **$ 158 505** |
| Nyarugenge | District Hospital | $ 21 900 | $ 31 500 | $ 17 160 | $ 193 049 | **$ 263 609** |
| **TOTAL** | | **$ 237 600** | **$ 295 000** | **$ 143 000** | **$ 1 576 569** | **$ 2 252 169** |

[28] The electricity cost assumption is based on REG's 2020 tariff for health facilities (RWF 186 per KwH + 18% VAT). If the medium-size industrial customer is used instead (RWF 103 + 18% VAT), then the total energy bill would be 44% lower. Source: https://www.reg.rw/customer-service/tariffs/

**Total cylinder transportation costs to district hospitals could reach nearly US$ 2 million annually in the base need scenario** (up to US$ 20 million in the high need scenario, illustrating the sensitivity of transportation costs to any increase in demand).[29] On average, in the base scenario, each district hospital would need to pay US$ 55,000 per year in transportation costs.

**OPEX at national level could, therefore, reach more than US$ 4 million annually in the base need scenario.** Given that OPEX are influenced by a number of factors such as actual oxygen need, PSA plant run time, electricity and fuel costs, this amount should be taken as a directional figure rather than a robust estimation that can be used for budgeting purposes. **Importantly, the above OPEX figure does not include the cost of health care worker training and mentorship, and the cost of buying oxygen consumables (e.g., masks, tubing, canulas).**

[29] Cylinder transportation cost is calculated for each catchment area based on actual driving distances between the PSA plant and the district hospitals in the catchment area and assumes a diesel cost of about US$1 per liter, a maximum truckload of 30 "J" size cylinders (2,340 kg), and a weekly refill of cylinders.

## Rwanda Oxygen PPP project

### Financial Projections

**Projection for 11 sites**

| in RWF unless otherwise stated | Year 1 2021 | Year 2 2022 | Year 3 2023 | Year 4 2024 | Year 5 2025 | Year 6 2026 | Year 7 2027 | Year 8 2028 | Year 9 2029 | Year 10 2030 | Year 11 2031 | 10 y Total | 10 y Total (abs.) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Gross Revenue p.a. from host hospital | 1,475,915,294 | 2,326,579,200 | 2,609,418,240 | 2,755,399,680 | 2,901,381,120 | 3,047,362,560 | 3,211,591,680 | 3,375,820,800 | 3,558,297,600 | 3,740,774,400 | 3,941,498,880 | 29,002,540,574 | 29,002,540,574 |
| Gross Revenue p.a. from cylinder distribution | 327,888,000 | 688,564,800 | 903,927,600 | 1,139,261,760 | 1,395,908,640 | 1,675,209,600 | 1,759,864,320 | 1,848,096,000 | 1,941,096,960 | 2,038,867,200 | 2,141,406,720 | 13,718,684,880 | 13,718,684,880 |
| **Net Revenue p.a.** | **1,803,803,294** | **3,015,144,000** | **3,513,345,840** | **3,894,661,440** | **4,297,289,760** | **4,722,572,160** | **4,971,456,000** | **5,223,916,800** | **5,499,394,560** | **5,779,641,600** | **6,082,905,600** | 42,721,225,454 | 42,721,225,454 |
| - Electricity Costs | -501,870,336 | -809,967,312 | -922,631,560 | -991,049,660 | -1,064,002,992 | -1,141,774,032 | -1,198,862,734 | -1,258,805,870 | -1,321,746,164 | -1,387,833,472 | -1,457,225,146 | - 10,598,544,132 | 10,598,544,132 |
| - Repair & maintenance costs | 0 | 0 | -53,900,000 | -56,595,000 | -59,424,750 | -62,395,988 | -65,515,787 | -68,791,576 | -72,231,155 | -75,842,713 | -79,634,848 | - 514,696,968 | 514,696,968 |
| - Labour Costs - Production | -183,456,000 | -287,708,400 | -302,093,820 | -317,198,511 | -333,058,437 | -349,711,358 | -367,196,926 | -385,556,773 | -404,834,611 | -425,076,342 | -446,330,159 | - 3,355,891,178 | 3,355,891,178 |
| **Gross Profit** | **1,118,476,958** | **1,917,468,288** | **2,234,720,460** | **2,529,818,269** | **2,840,803,582** | **3,168,690,782** | **3,339,880,553** | **3,510,762,581** | **3,700,582,630** | **3,890,889,073** | **4,099,715,447** | 28,252,093,176 | 28,252,093,176 |
| *Gross Profit Margin* | *62%* | *64%* | *64%* | *65%* | *66%* | *67%* | *67%* | *67%* | *67%* | *67%* | *67%* | *66%* | |
| - Labour Costs - Sales, Distribution & Admin | -83,496,000 | -87,670,800 | -92,054,340 | -96,657,057 | -101,489,910 | -106,564,405 | -111,892,626 | -117,487,257 | -123,361,620 | -129,529,701 | -136,006,186 | - 1,050,203,715 | 1,050,203,715 |
| - O2 transportation Costs | -97,369,008 | -140,949,917 | -169,837,391 | -201,261,237 | -235,402,875 | -272,455,524 | -286,078,300 | -300,382,215 | -315,401,326 | -331,171,392 | -347,729,961 | - 2,350,309,184 | 2,350,309,184 |
| - Selling, General Admin and Professional Costs | -23,918,033 | -36,325,440 | -41,616,158 | -45,753,449 | -50,120,074 | -54,730,257 | -57,594,322 | -60,512,918 | -63,681,384 | -66,918,226 | -70,406,956 | - 501,170,263 | 501,170,263 |
| **EBITDA** | **913,693,917** | **1,652,522,131** | **1,931,212,571** | **2,186,146,525** | **2,453,790,722** | **2,734,940,596** | **2,884,315,305** | **3,032,380,190** | **3,198,138,301** | **3,363,269,755** | **3,545,572,343** | 24,350,410,014 | 24,350,410,014 |
| *EBITDA Margin* | *51%* | *55%* | *55%* | *56%* | *57%* | *58%* | *58%* | *58%* | *58%* | *58%* | *58%* | *57%* | |
| - Loan interest repayment | -1,164,542,118 | -1,078,787,993 | -843,127,914 | -564,131,897 | -233,830,820 | -2,747,546 | 0 | 0 | 0 | 0 | 0 | - 3,887,168,287 | 3,887,168,287 |
| - Asset depreciation | -365,797,740 | -365,797,740 | -365,797,740 | -365,797,740 | -365,797,740 | -365,797,740 | -365,797,740 | -365,797,740 | -365,797,740 | -365,797,740 | -365,797,740 | - 3,657,977,400 | 3,657,977,400 |
| **EBT** | **(616,645,941)** | **207,936,399** | **722,286,917** | **1,256,216,888** | **1,854,162,163** | **2,366,395,310** | **2,518,517,565** | **2,666,582,450** | **2,832,340,561** | **2,997,472,015** | **3,179,774,603** | 16,805,264,327 | 16,805,264,327 |
| - Income Tax | 0 | 0 | -216,686,075 | -376,865,066 | -556,248,649 | -709,918,593 | -755,555,270 | -799,974,735 | -849,702,168 | -899,241,604 | -953,932,381 | - 5,164,192,161 | 5,164,192,161 |
| **Net Income/Loss** | **(616,645,941)** | **207,936,399** | **505,600,842** | **879,351,822** | **1,297,913,514** | **1,656,476,717** | **1,762,962,296** | **1,866,607,715** | **1,982,638,393** | **2,098,230,410** | **2,225,842,222** | 11,641,072,166 | 11,641,072,166 |
| *Net Income Margin* | *-34%* | *7%* | *14%* | *23%* | *30%* | *35%* | *35%* | *36%* | *36%* | *36%* | *37%* | *27%* | |
| + Asset depreciation | 365,797,740 | 365,797,740 | 365,797,740 | 365,797,740 | 365,797,740 | 365,797,740 | 365,797,740 | 365,797,740 | 365,797,740 | 365,797,740 | 365,797,740 | 3,657,977,400 | 3,657,977,400 |
| + Investor's equity | 2,638,116,196 | | | | | | | | | | | 2,638,116,196 | 2,638,116,196 |
| + Loan receipt | 7,914,348,587 | | | | | | | | | | | 7,914,348,587 | 7,914,348,587 |
| + Grant receipt | 0 | | | | | | | | | | | - | - |
| - Capital expenditure | -10,552,464,782 | | | | | | | | | | | - 10,552,464,782 | 10,552,464,782 |
| - Loan principal repayment | -999,069,309 | -1,281,515,382 | -1,517,175,460 | -1,796,171,478 | -2,126,472,555 | -193,944,402 | 0 | 0 | 0 | 0 | 0 | - 7,914,348,587 | 7,914,348,587 |
| - Shareholder dividends | 0 | 0 | 0 | 0 | 0 | -263,811,620 | -263,811,620 | -263,811,620 | -263,811,620 | -263,811,620 | -263,811,620 | - 1,319,058,098 | 1,319,058,098 |
| **Free cash flow (RWF)** | **(1,249,917,510)** | **(707,781,244)** | **(645,776,879)** | **(551,021,916)** | **(462,761,301)** | **1,564,518,435** | **1,864,948,416** | **1,968,593,836** | **2,084,624,513** | **2,200,216,531** | **2,327,828,343** | 6,065,642,882 | 6,065,642,882 |
| Free cash flow (US$) | (1,275,426) | (722,226) | (658,956) | (562,267) | (472,205) | 1,596,447 | 1,903,009 | 2,008,769 | 2,127,168 | 2,245,119 | 2,375,335 | | |

### b. Develop sustainable financing for oxygen delivery systems

Three broad financing sources can be tapped into to fund this strategy: domestic resources, private capital and health development partners (donations, grants, concessional debts, etc.).

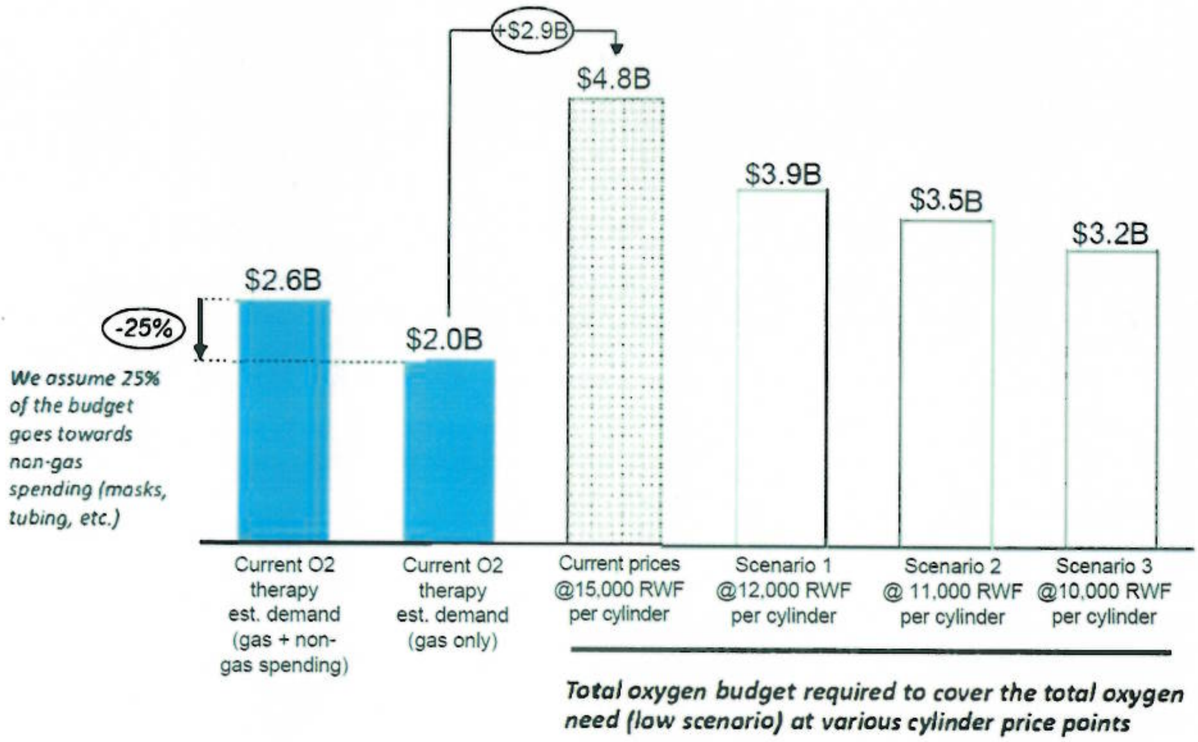
***Domestic resources***

The GoR through the Ministry of health will procure, own, operate and expand already existing PSA plants at University Teaching Hospitals such as CHUB, CHUK, and King Faisal. In 2021 alone, GoR invested US$ 310,000 to optimize and expand King Faisal Hospital's PSA plant capacity.

Oxygen therapy is already covered by existing health insurance schemes, mainly CBHI. In FY2019/20, an estimated RWF 2 billion of recoverable costs linked to medical oxygen were claimed by hospitals from the different health insurance schemes. It is not clear whether this amount should be considered a maximum, or if the national insurance schemes have the financial capacities to increase their allocations to oxygen, should the need arise.

As shown on Figure 9 below, the total oxygen budget required to cover the national oxygen need in the low scenario stands at about RWF 3.5 billion. In other words, health insurances appear to have the capacity to cover a substantial portion of the national oxygen budget.

Figure 9 – Total oxygen therapy costs, including estimated demand for cylinders at various price points, required to cover country-wide needs (RWF)




*Note: the price points in the above chart represent unit prices for a large "J" size cylinder. The current median market price is RWF 15,000 per large cylinder (greyed bar).*

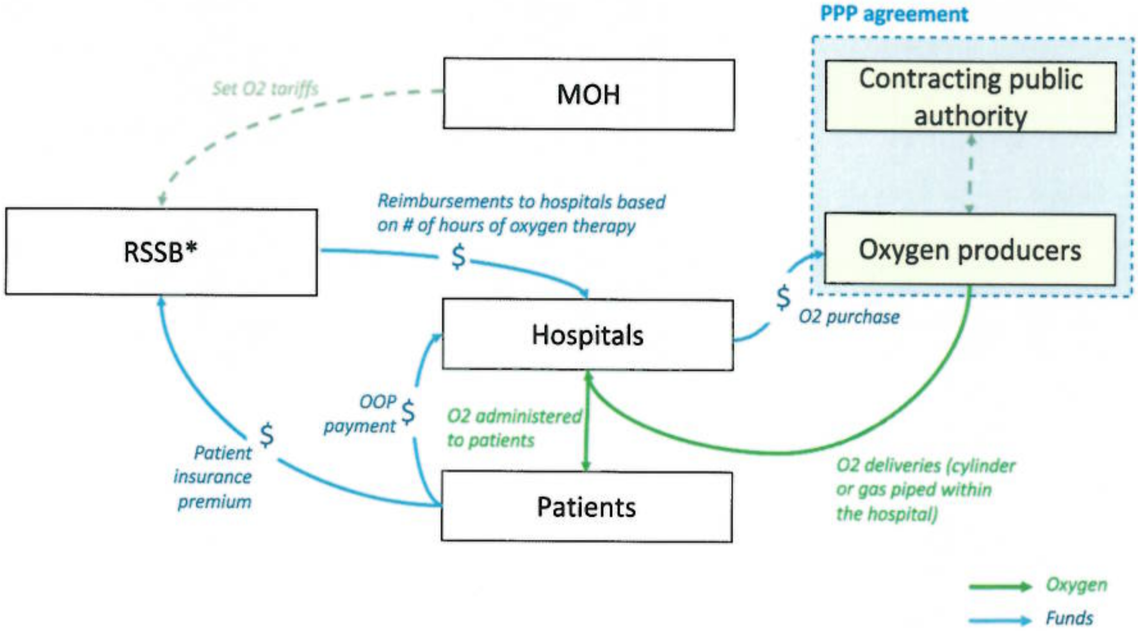
However, to increase the sustainability of this financing source, the **oxygen therapy tariff should be revised.** As discussed in previous section, the oxygen tariffs are currently set per hour of oxygen therapy (RWF 635 / hour with CBHI), whereas oxygen is purchased by the cubic meter or cylinder. This misalignment could push hospitals into a loss when they treat many adult patients requiring high flow rates. At least three tariff reform options are available:

1. No change in tariff formula + tariff increase to mitigate the risks of financial loss. While this option is the easiest to implement (no additional data collection needed at hospital level), it would be the least efficient from a resource allocation perspective.
2. Tariff calculation formula takes into account both the oxygen therapy duration (in hours) & the patient age group and patient category which would be used as a proxy for flow rates and overall consumption. The new formula could provide a tariff scale such as: lowest tariff for newborn/pediatric patients, medium tariff for non-critical adult patient, and highest tariff for critical adult patients. The main advantage of this option is its relative ease of implementation at health facility level as it would require limited additional data collection by health practitioners.
3. Tariff calculation formula is solely based on each patient's oxygen consumption in liters. While this option would allow a perfect alignment between oxygen costs and insurance claims, it is also the least practical as actual oxygen consumption is not measured and such measurement would be costly to implement.

***Private capital***

In a Build-Operate-Transfer PPP model, the CAPEX and most of the OPEX are borne by the private investors, who recoup their costs by charging a pre-determined monthly fee or price per cubic meter delivered (or a mix of both) to the hospitals in return for a reliable supply of oxygen (see Diagram 4).

Diagram 4 – Simplified oxygen financing flows under a PPP model




RSSB: Rwanda Social Security Board (RSSB)

The private companies can finance their upfront investment by raising equity, securing commercial or concessional debt or using their own capital. RVO and DFC have expressed interest in financing private sector-led oxygen projects. The typical structure of financing can be small grants to fund feasibility studies, debt financing, equity financing, investment in private equity funds and political risk insurance The value of financing varies greatly, starting from a minimum of US$ 5 million and terms of anywhere from 1.5 to 25 years.

When properly designed and negotiated, PPPs have the potential to accelerate key infrastructure development without increasing public debt. It should be stressed, however, that PPPs do create off-balance-sheet liabilities for the Government, often in the shape of a commitment to purchase minimum annual quantities to the private companies. Keeping debt off-balance-sheet does not reduce actual liabilities for the Government and may merely disguise government liabilities, reducing the effectiveness of government debt monitoring mechanisms. For this reason, the terms and conditions of the PPP agreement should be carefully examined by the relevant public bodies per the national regulations.

***Health Development Partners***

Major donors to the oxygen space who have or are able to provide either grant or debt financing in Rwanda currently include World Bank, UNITAID, Global Fund, USAID. Additional partners have contributed to the oxygen ecosystem or expressed a willingness to provide technical assistance, including WHO, CHAI and PIH.

Since the start of 2021, GoR has submitted funding application to several funders, including:

- *Access to Covid-19 Tools accelerator (ACT accelerator)*: the WHO with its partners launched in April 2020 an effort called ACT accelerator to help countries respond to the Covid-19 pandemic. In its US$ 11 million application, GoR prioritized oxygen infrastructure spending such as oxygen piping and cylinders, as well as key respiratory care equipment and consumables (see Appendix 5 for further details).
- *World Bank:* Rwanda has applied for grants that will expand the oxygen production within the country, particularly around isolation units and piping.

### c. Resource Mobilization strategy

***Plan for Resource Mobilization***

The successful execution of this strategy will require optimal funding for each part of the implementation plan to be executed in a coordinated and sustained manner. This plan envisions mobilizing such resources by advocating for 1) increased government allocations and disbursements; 2) domestic resource mobilization from non-state actors; 3) sustained or increased levels of funding from foreign sources, including development partners. A financial program gap analysis should be conducted on an annual basis to inform resource allocation and mobilization efforts. Further, a sub-working group should be established to steer and coordinate multi-stakeholder efforts focused on resource mobilization and financing for oxygen.

The sub-working group should specifically be responsible for:

- Pooling demand for oxygen, equipment and delivery interfaces in order to leverage opportunities for price negotiation, volume guarantees, and other vehicles for market shaping to ensure the sustainable cost of oxygen
- Supporting hospitals with resources to guide:
    - Advance planning for operational costs for the lifetime of oxygen sources (PSA plants, concentrators)
    - Advance planning for distribution costs for PSA plants
    - Advance planning for repair, maintenance and spare parts for all durable equipment to ensure investments are maximized

- Tracking and encouraging public and private health sector financial contributions to oxygen therapy and tracking unmet demand to influence increased investment over time to match demand for both diagnosis and treatment.
- Landscaping alternative funding sources and innovative funding structures (e.g., RVO, DFC) to accelerate investments public and private sector oxygen investments.

## X. Monitoring and Evaluation

To ensure effective implementation of this national medical oxygen scale-up plan and measure its impact, indicators to measure the plan output and outcomes are below. To ensure effective tracking of the implementation of this strategy, all indicators will be integrated with the existing HMIS for service delivery and health outcome and MEMMS for medical equipment availability, management, and maintenance.

Clinical Outcomes:

- Number of patients receiving oxygen therapy per facility per year, by gender and age
- Hypoxemia screening rate: proportion of patients who received pulse oximetry on admission
- Oxygen coverage rate: % of hypoxemic patients who received oxygen therapy

Protocols and guidelines

- Availability and dissemination of protocols/SOPs/guidelines on hypoxemia screening and oxygen administration
- Minimum standards developed for medical oxygen equipment, incl. vital signs monitors

Medical Oxygen plants:

- Number of functioning oxygen plants at referral, provincial and district hospitals
- Percentage of functioning oxygen plants at referral, provincial and district hospitals (out of total plants)
- Proportion of oxygen plants that are functional
- Proportion of planned plants that are operational
- Total public medical oxygen production per year compared to the need (L)
- Median oxygen purchasing price

Financial sustainability:

- Oxygen therapy tariff by insurance type
- Health facility net revenue on oxygen (RWF)
- Total mobilized budget for oxygen scale-up (RWF)

Equipment:

- Percentage of health facilities meeting minimum requirements for oxygen equipment standards

- Percentage of functioning oxygen equipment procured and distributed, by equipment type
- Equipment uptime

Infrastructure:

- Percentage of referral, provincial and district hospitals that have piped oxygen to wards with high oxygen consumption

Trainings:

- Percentage of targeted clinicians that completed medical oxygen training
- Number of BMEs that completed training for medical oxygen equipment maintenance
- Proportion of clinicians with demonstrable competencies in hypoxemia management

## XI. Project Risks

### viii. Project Objectives

1. Create an enabling policy environment and a national coordination mechanism
2. Increase national oxygen production capacities and implement optimal operating models
3. Develop sustainable financing for oxygen delivery systems
4. Improve availability of high-quality diagnostics and oxygen distribution & delivery systems
5. Provide a framework for training of health care workers in health facilities on rational use of oxygen

### ix. Project Objectives, Risks, and Mitigation Strategy

| Project Objectives | Risk | Mitigation Strategy |
|---|---|---|
| **1. Create an enabling policy environment and a national coordination mechanism** | Ineffective policy environment and a national coordination mechanism | Establish Oxygen Technical Working with diverse expertise under MoH and RBC chair to ensure effective coordination and monitoring and advise conducive policy environment for this plan implementation |
| **2. Increase national oxygen production capacities and implement optimal operating models** | Regional demand for new plants too low to ensure financial sustainability of plants with a price below private supplier | Ensure high oxygen utilization and if business analysis proves financial viability at or below private supplier prices<br><br>If public demand is met, considering selling to private HFs |

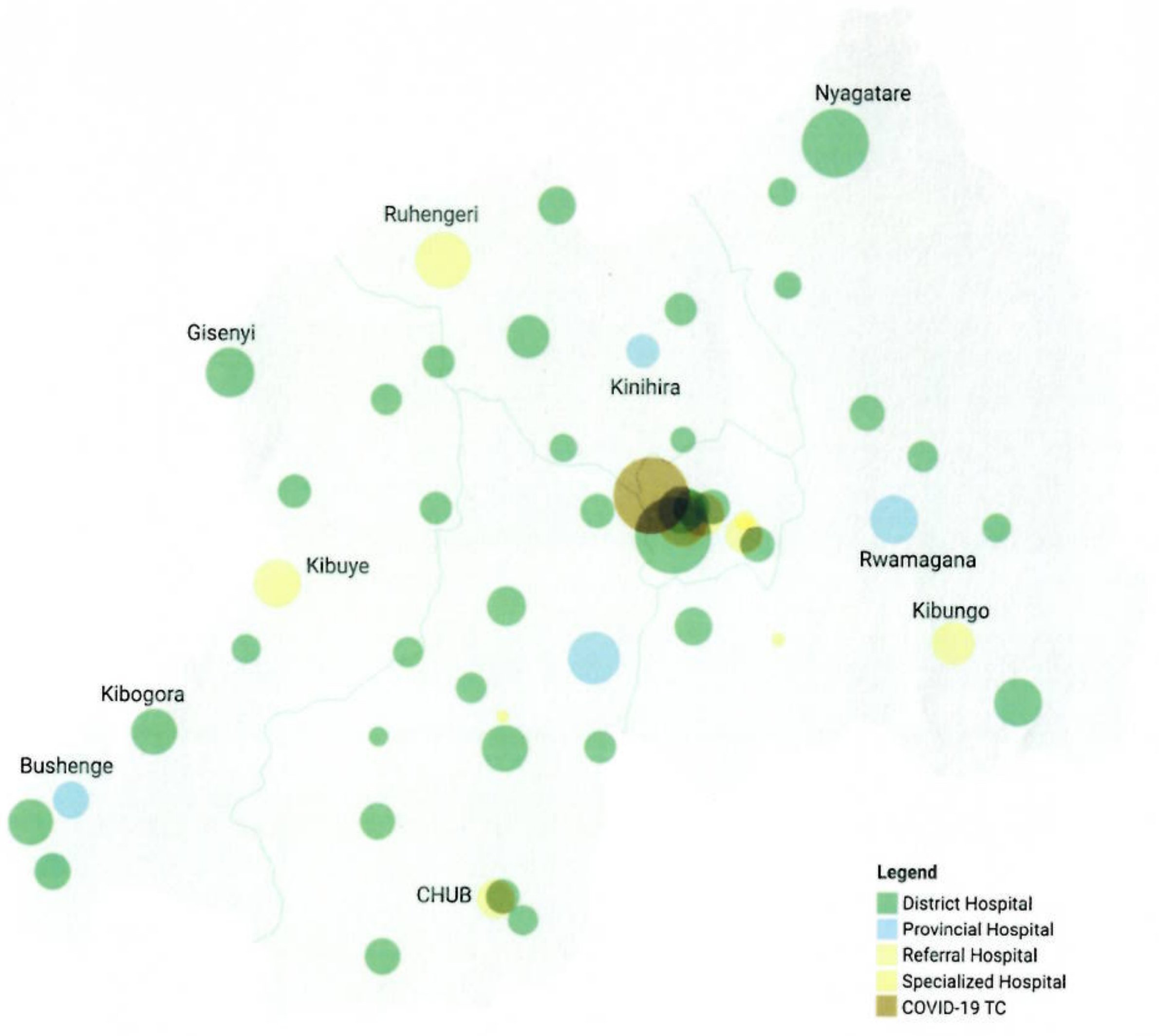
| | | |
|---|---|---|
| **3. Increase national oxygen production capacities and implement optimal operating models** | Oxygen Plants operate below desired capacity due to:<br>• Maintenance capacity issues<br>• Spare parts issues<br>• Power issues<br>• Poor demand generation<br>• Distribution issues<br>• Etc. | • Ensure BMEs are trained to operate and maintain plants<br>• Ensure spare parts can be procured rapidly<br>• Develop SOPs for the production and distribution of oxygen for hospitals with plants |
| **4. Improve availability of high-quality diagnostics and oxygen distribution & delivery systems** | HCs do not use vital signs monitors:<br>• vital signs monitors at HCs breakdown and are not repaired<br>• vital signs monitors not sufficient/not available<br>• staff do not find vital signs monitors easy to use<br>• no power source for vital signs monitors<br>HCs do not use oxygen equipment<br>Lack of funding dedicated to durable equipment<br>Global shortages of durable equipment due to respiratory epidemics<br>Unprecedented demand for oxygen beyond predicted consumption<br>Lack of specialized tools and resources available at facility level for repair and maintenance<br>Lack of equipment inventory control and asset management system which is interoperable with existing government data systems | • Trainings for clinicians in HCs<br>• Train DH BMEs how to maintain vital signs monitors at HCs<br>• Trainings for clinicians in HCs, BME/Ts to support and assist with troubleshooting, training should be accounted for at procurement stage, particularly for specialized equipment such as ventilators<br>• Active resource mobilization should be managed by sub-working group<br>• Diverse and robust procurement mechanisms which leverage all sources of quality equipment can be more resilient to supply disruptions; Ministry of Health and HCs should leverage pandemic preparedness plans to expand and triage facility capacity as needed<br>• Specialized tools and resources should be carefully planned based on available constraints and regional or mobile hubs established where possible to share existing resources<br>• Existing systems should be carefully evaluated, system interoperability must be considered and all relevant bodies of government such as RBC, MOH, RMS should be involved in the development and implementation of any equipment management system |
| **5. Provide a framework for training of health care workers in health facilities on rational use of oxygen** | Lack of training framework for training of health care workers in health facilities on rational use of oxygen:<br>• Lack of enough fund to support training | • Government and partner should work together to allocate funding for capacity development of healthcare workers on oxygen therapy. |

| | | |
|---|---|---|
| | • Training do not reach clinicians at all levels of care | • Work closely with HRH secretariat to ensure oxygen therapy is integrated in curriculum of both academic and professional training.<br>• Clinical guidelines and job aid on oxygen therapy should be available alongside regular refresher cascade training |

# XII. Appendix

## Appendix 1 – Geographic spread of oxygen need

*Bubbles represent health facilities. The size of the bubbles represents the size of the total oxygen need.*



## Appendix 2 - Workplan

| No. | Objectives and Main Activities | Output | Lead | Year 1 2021 | Year 2 2022 | Year 3 2023 | Year 4 2024 | Year 5 2025 |
|---|---|---|---|---|---|---|---|---|
| **Objective 1: Create an enabling policy environment and a national coordinating mechanism** | | | | | | | | |
| 01.1 | Develop standard operating procedures (SOPs) and protocols for oxygen use in health facilities | Clinical guidelines and job aids for oxygen therapy, SOPs for management of medical oxygen | MOH | | | | | |
| 01.2 | Develop national technical specifications and procurement processes for medical oxygen equipment | National technical specification documents, supplier pre-qualification processes, essential oxygen therapy lists | MOH | | | | | |
| 01.3 | Create coordinating mechanisms for oxygen scale-up at national and regional levels | National coordinating mechanism | MOH and RBC | | | | | |
| **Objective 2: Increase national oxygen production capacities and implement optimal operating models** | | | | | | | | |
| 02.1 | Select and implement optimal oxygen production and distribution models | 11 PSA plant installations | MOH, RBC | | | | | |
| 02.2 | Establish a public-private-partnership (PPP) for oxygen | Oxygen PPP | RSSB, RBC, RMS, MOH, RDB | | | | | |
| **Objective 3: Develop sustainable financing for oxygen delivery systems** | | | | | | | | |
| 03.1 | Refine and validate preliminary oxygen strategy costing | Finalized strategy costing | MOH, RMS, RDB | | | | | |
| 03.2 | Revise oxygen therapy tariff to cover the cost of oxygen | Revised tariff | MOH | | | | | |
| 03.3 | Advocate to the REG to reduce the cost of electricity per kW | Lower electricity rate for hospitals (e.g. 44% of current health facility rate) | MOH, RDB | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 03.4 | Assess BME workforce capacity | | MOH, RBC | | | | | |
| 03.5 | Revise oxygen plant maintenance contracts and MTD roles and responsibilities based on identified need | Revised contracts | MOH, RDB | | | | | |
| 03.6 | Provide guidance to hospitals to facilitate the allocation of budgets to maintenance of medical oxygen equipment and infrastructure | Budget guidance, revised budgets | MOH | | | | | |
| 03.7 | Identify funding gap between committed funding from the MOH and projected funding needs | Funding analysis | MOH | | | | | |
| 03.8 | Establish sub-working group to coordinate multi-stakeholder efforts around resource mobilization and financing | Sub-working group with regularly planned meetings | MOH | | | | | |
| 03.9 | Establish a framework for identifying and pursuing private sector financing opportunities for oxygen | Frameworks | MOH, RDB | | | | | |
| **Objective 4: Improve availability of high-quality diagnostics and oxygen distribution & delivery systems** | | | | | | | | |
| 04.1 | Install oxygen piping system in critical wards (ICU, surgery, emergency) followed by maternal, pediatric and neonatal ward in all hospitals | Installed pipe networks, on per ward, including associated manifolds and cylinders | MOH, RBC | | | | | |
| 04.2 | Revise and update procurement and deployment plan for oxygen equipment | Procured pulse oximeters, patient monitors, CPAP machines, ventilators, HFNCs, | MOH, RBC | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 04.3 | Develop training schedule for BME/Ts to develop capacity for regular equipment maintenance | Trainings' plan | MOH, RBC | | | | | |
| 04.4 | Establish guidelines for quantifying equipment according to oxygen consumption and clinical need | Guidelines for equipment quantification | MOH, RBC | | | | | |
| 04.5 | Establish quality assurance and control guidelines and processes for equipment management | Quality assurance and control guidelines | MOH, Rwanda FDA, MTD | | | | | |
| 04.6 | Refine asset management data systems to include equipment inventory control & asset management and maintenance data for oxygen equipment | Revised data system (MEMMS) | MOH, RBC | | | | | |
| 04.7 | Disseminate clinical guidance for the use of medical equipment, clinical flow, technical and operational requirements | Clinical guidance in each health facility | MOH | | | | | |
| 04.8 | Optimize utilization of the Medical Equipment Management and Maintenance System (MEMMS) and expand its utilization to clinicians as end users. | MEMMS Optimized | RBC | | | | | |
| 04.9 | Establish a monitoring mechanism to provide on the job training and performance management | | MOH, RBC | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 04.10 | Capacity building of clinicians to use oxygen equipment correctly to diagnose hypoxemia and provide oxygen therapy | Clinician trained and improved practice | MOH | | | | | |
| 04.11 | Cost operations, spare parts, tools, replacements and other necessary components of equipment maintenance for existing equipment and ensure inclusion in procurement and ensure inclusion in warranties and service agreements for new procurements | | RBC | | | | | |
| **Objective 5: Provide a framework for training of health care workers in health facilities on rational use of oxygen** | | | | | | | | |
| 05.1 | Develop clinician training modules and checklists on the provision of medical oxygen therapy | Training modules and checklists | MOH | | | | | |
| 05.2 | Delivery of specialized first-level trainings to medical equipment end users and maintenance staff | Completed training materials, regularly facilitated trainings | Local suppliers | | | | | |
| 05.3 | Refine advanced trainings modules for 2-3 BME/Ts for each brand of oxygen plants | Completed training materials, regularly facilitated trainings | RBC, Local suppliers | | | | | |
| **M&E** | | | | | | | | |
| 06.1 | Develop M&E indicators and measures of success | Finalized indicators | MOH | | | | | |
| 06.2 | Begin collecting routine data on indicators into HMIS | | MOH | | | | | |
| 06.3 | Ongoing M&E of project indicators | | MOH, RBC | | | | | |

## Appendix 3 – CAPEX

| ID | Health Facility Name | Back-up generator | Contenarized plant ("plug & play") | Construction work (plant building, power | Hospital piping network | Delivery truck | Cylinders | TOTAL CAPEX |
|---|---|---|---|---|---|---|---|---|
| H-1 | KINIHIRA | $ 15.000 | $ 30.000 | $ 5.000 | $ 189.000 | $ 55.000 | $ 109.940 | $ 527.440 |
| H-2 | BUTARO | $ - | $ - | $ - | $ 144.000 | $ - | $ - | $ 144.000 |
| H-3 | BYUMBA | $ - | $ - | $ - | $ 293.400 | $ - | $ - | $ 293.400 |
| H-4 | GAHINI | $ - | $ - | $ - | $ 203.400 | $ - | $ - | $ 203.400 |
| H-5 | GAKOMA | $ - | $ - | $ - | $ 99.000 | $ - | $ - | $ 99.000 |
| H-6 | GIHUNDWE | $ - | $ - | $ - | $ 255.600 | $ - | $ - | $ 255.600 |
| H-7 | GISENYI | $ - | $ - | $ - | $ 300.600 | $ - | $ - | $ 300.600 |
| H-8 | GITWE | $ - | $ - | $ - | $ 219.600 | $ - | $ - | $ 219.600 |
| H-9 | KABAYA | $ - | $ - | $ - | $ 151.200 | $ - | $ - | $ 151.200 |
| H-10 | KABGAYI | $ 25.000 | $ 30.000 | $ 5.000 | $ 300.600 | $ 55.000 | $ 120.060 | $ 782.660 |
| H-11 | KABUTARE | $ - | $ - | $ - | $ 205.200 | $ - | $ - | $ 205.200 |
| H-12 | KACYIRU | $ - | $ - | $ - | $ 282.600 | $ - | $ - | $ 282.600 |
| H-13 | KADUHA | $ - | $ - | $ - | $ 145.800 | $ - | $ - | $ 145.800 |
| H-14 | KIBAGABAGA | $ - | $ - | $ - | $ 138.914 | $ - | $ - | $ 138.914 |
| H-15 | KIBILIZI | $ - | $ - | $ - | $ 120.600 | $ - | $ - | $ 120.600 |
| H-16 | KIBOGORA | $ - | $ - | $ - | $ 286.200 | $ - | $ - | $ 286.200 |
| H-17 | KIGEME | $ - | $ - | $ - | $ 214.200 | $ - | $ - | $ 214.200 |
| H-18 | KIREHE | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| H-19 | KIRINDA | $ - | $ - | $ - | $ 169.200 | $ - | $ - | $ 169.200 |
| H-20 | KIZIGURO | $ - | $ - | $ - | $ 77.460 | $ - | $ - | $ 77.460 |
| H-21 | MASAKA | $ - | $ - | $ - | $ 216.000 | $ - | $ - | $ 216.000 |
| H-22 | MIBIRIZI | $ - | $ - | $ - | $ 198.000 | $ - | $ - | $ 198.000 |
| H-23 | MUGONERO | $ - | $ - | $ - | $ 133.200 | $ - | $ - | $ 133.200 |
| H-24 | MUHIMA | $ - | $ - | $ - | $ 360.000 | $ - | $ - | $ 360.000 |
| H-25 | MUHORORO | $ - | $ - | $ - | $ 124.200 | $ - | $ - | $ 124.200 |
| H-26 | MUNINI | $ - | $ - | $ - | $ 97.200 | $ - | $ - | $ 97.200 |
| H-27 | MURUNDA | $ - | $ - | $ - | $ 172.800 | $ - | $ - | $ 172.800 |
| H-28 | NEMBA | $ - | $ - | $ - | $ 189.613 | $ - | $ - | $ 189.613 |
| H-29 | NGARAMA | $ - | $ - | $ - | $ 134.524 | $ - | $ - | $ 134.524 |
| H-30 | NYAGATARE | $ 35.000 | $ - | $ 10.000 | $ 229.301 | $ 55.000 | $ 188.370 | $ 845.271 |
| H-31 | NYAMATA | $ - | $ - | $ - | $ 232.200 | $ - | $ - | $ 232.200 |
| H-32 | NYANZA | $ - | $ - | $ - | $ 228.600 | $ - | $ - | $ 228.600 |
| H-33 | REMERA RUKOMA | $ - | $ - | $ - | $ 171.000 | $ - | $ - | $ 171.000 |
| H-34 | RULI | $ - | $ - | $ - | $ 223.200 | $ - | $ - | $ 223.200 |
| H-35 | RUTONGO | $ - | $ - | $ - | $ 135.000 | $ - | $ - | $ 135.000 |
| H-36 | RWINKWAVU | $ - | $ - | $ - | $ 145.640 | $ - | $ - | $ 145.640 |
| H-37 | SHYIRA | $ - | $ - | $ - | $ 46.200 | $ - | $ - | $ 46.200 |
| H-38 | BUSHENGE | $ 35.000 | $ - | $ 10.000 | $ 48.852 | $ 55.000 | $ 478.170 | $ 954.622 |
| H-39 | RUHANGO | $ 35.000 | $ - | $ 10.000 | $ - | $ 55.000 | $ 392.380 | $ 819.980 |
| H-40 | RWAMAGANA | $ 35.000 | $ - | $ 10.000 | $ 221.400 | $ 55.000 | $ 282.900 | $ 891.600 |
| H-41 | CHUB | $ 35.000 | $ - | $ 10.000 | $ 191.073 | $ 55.000 | $ 365.010 | $ 851.083 |
| H-42 | CHUK | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| H-43 | Hôpital Ndera (Mental health) | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| H-44 | KIBUNGO | $ 25.000 | $ 30.000 | $ 5.000 | $ 280.800 | $ 55.000 | $ 45.310 | $ 688.110 |
| H-45 | KIBUYE | $ 25.000 | $ 30.000 | $ 5.000 | $ 212.400 | $ 55.000 | $ 266.570 | $ 840.970 |
| H-46 | King Faysal | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| H-47 | RMH | $ - | $ - | $ - | $ - | $ - | $ - | $ - |
| H-48 | RUHENGERI | $ 25.000 | $ 30.000 | $ 5.000 | $ 76.948 | $ 55.000 | $ 366.160 | $ 721.908 |
| H-49 | Gatagara Orthopedic and Rehabilitation Hospital | $ - | $ - | $ - | $ 3.600 | $ - | $ - | $ 3.600 |
| H-50 | Inkurunziza Orthopedic Hospital | $ - | $ - | $ - | $ 18.000 | $ - | $ - | $ 18.000 |
| H-51 | Ririma orthopedic Center | $ - | $ - | $ - | $ 3.600 | $ - | $ - | $ 3.600 |
| H-52 | Gatunda | $ - | $ - | $ - | $ 145.800 | $ - | $ - | $ 145.800 |
| H-53 | Kanyinya | $ - | $ - | $ - | $ 84.000 | $ - | $ - | $ 84.000 |
| H-54 | Nyarugenge | $ 35.000 | $ 30.000 | $ 5.000 | $ - | $ - | $ 133.860 | $ 531.460 |
| | TOTAL | $ 325.000 | $ 180.000 | $ 80.000 | $ 8.119.726 | $ 550.000 | $ 2.748.730 | $ 14.824.456 |

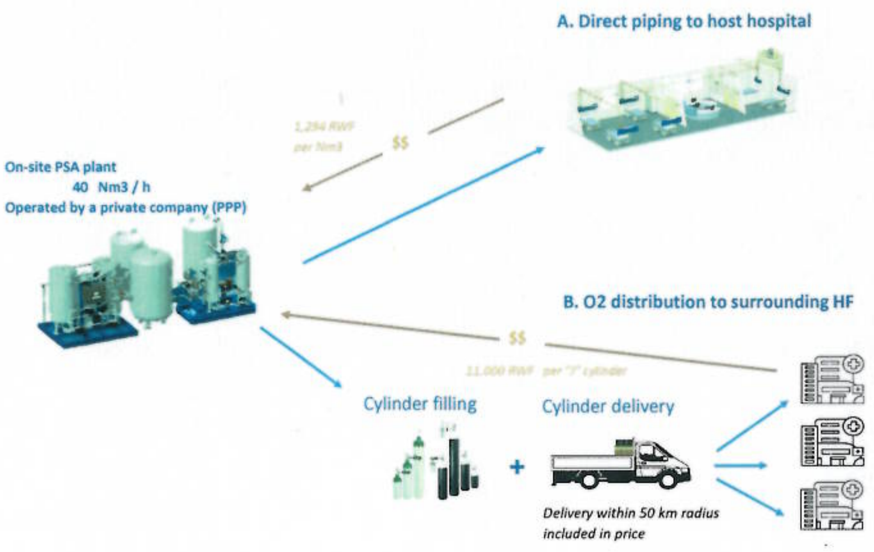
## Appendix 4 – Annual OPEX

| ID | Health Facility Name | Annual staff cost | Annual Maintenance | Training (one-off) | Cylinder transport & delivery | Power (assuming run time of 18h / day | TOTAL annual OPEX |
|---|---|---|---|---|---|---|---|
| H-1 | KINIHIRA | $ 19,500 | $ 16,000 | $ 5,850 | $ - | $ 60,328 | $ 101,678 |
| H-2 | BUTARO | $ - | $ - | $ - | $ - | $ - | $ - |
| H-3 | BYUMBA | $ - | $ - | $ - | $ 452,465 | $ - | $ 452,465 |
| H-4 | GAHINI | $ - | $ - | $ - | $ 477,614 | $ - | $ 477,614 |
| H-5 | GAKOMA | $ - | $ - | $ - | $ 585,280 | $ - | $ 585,280 |
| H-6 | GIHUNDWE | $ - | $ - | $ - | $ 683,891 | $ - | $ 683,891 |
| H-7 | GISENYI | $ - | $ - | $ - | $ - | $ - | $ - |
| H-8 | GITWE | $ - | $ - | $ - | $ 493,135 | $ - | $ 493,135 |
| H-9 | KABAYA | $ - | $ - | $ - | $ 1,000,054 | $ - | $ 1,000,054 |
| H-10 | KABGAYI | $ 19,500 | $ 16,000 | $ 11,700 | $ - | $ 120,656 | $ 167,856 |
| H-11 | KABUTARE | $ - | $ - | $ - | $ 45,615 | $ - | $ 45,615 |
| H-12 | KACYIRU | $ - | $ - | $ - | $ 94,626 | $ - | $ 94,626 |
| H-13 | KADUHA | $ - | $ - | $ - | $ 379,939 | $ - | $ 379,939 |
| H-14 | KIBAGABAGA | $ - | $ - | $ - | $ 146,420 | $ - | $ 146,420 |
| H-15 | KIBILIZI | $ - | $ - | $ - | $ 179,447 | $ - | $ 179,447 |
| H-16 | KIBOGORA | $ - | $ - | $ - | $ 1,687,600 | $ - | $ 1,687,600 |
| H-17 | KIGEME | $ - | $ - | $ - | $ 954,913 | $ - | $ 954,913 |
| H-18 | KIREHE | $ - | $ - | $ - | $ - | $ - | $ - |
| H-19 | KIRINDA | $ - | $ - | $ - | $ 758,443 | $ - | $ 758,443 |
| H-20 | KIZIGURO | $ - | $ - | $ - | $ 1,098,716 | $ - | $ 1,098,716 |
| H-21 | MASAKA | $ - | $ - | $ - | $ 153,189 | $ - | $ 153,189 |
| H-22 | MIBIRIZI | $ - | $ - | $ - | $ 527,128 | $ - | $ 527,128 |
| H-23 | MUGONERO | $ - | $ - | $ - | $ 419,183 | $ - | $ 419,183 |
| H-24 | MUHIMA | $ - | $ - | $ - | $ 151,216 | $ - | $ 151,216 |
| H-25 | MUHORORO | $ - | $ - | $ - | $ 970,483 | $ - | $ 970,483 |
| H-26 | MUNINI | $ - | $ - | $ - | $ 1,376,400 | $ - | $ 1,376,400 |
| H-27 | MURUNDA | $ - | $ - | $ - | $ 1,037,035 | $ - | $ 1,037,035 |
| H-28 | NEMBA | $ - | $ - | $ - | $ 1,180,872 | $ - | $ 1,180,872 |
| H-29 | NGARAMA | $ - | $ - | $ - | $ 570,099 | $ - | $ 570,099 |
| H-30 | NYAGATARE | $ 21,900 | $ 31,500 | $ 17,160 | $ - | $ 193,049 | $ 263,609 |
| H-31 | NYAMATA | $ - | $ - | $ - | $ 910,557 | $ - | $ 910,557 |
| H-32 | NYANZA | $ - | $ - | $ - | $ 1,649,350 | $ - | $ 1,649,350 |
| H-33 | REMERA RUKOMA | $ - | $ - | $ - | $ 850,880 | $ - | $ 850,880 |
| H-34 | RULI | $ - | $ - | $ - | $ 607,324 | $ - | $ 607,324 |
| H-35 | RUTONGO | $ - | $ - | $ - | $ 304,646 | $ - | $ 304,646 |
| H-36 | RWINKWAVU | $ - | $ - | $ - | $ 532,042 | $ - | $ 532,042 |
| H-37 | SHYIRA | $ - | $ - | $ - | $ 489,365 | $ - | $ 489,365 |
| H-38 | BUSHENGE | $ 21,900 | $ 31,500 | $ 17,160 | $ - | $ 193,049 | $ 263,609 |
| H-39 | RUHANGO | $ 21,900 | $ 31,500 | $ 17,160 | $ - | $ 193,049 | $ 263,609 |
| H-40 | RWAMAGANA | $ 21,900 | $ 31,500 | $ 14,430 | $ - | $ 156,853 | $ 224,683 |
| H-41 | CHUB | $ 28,200 | $ 42,000 | $ 10,400 | $ - | $ 128,699 | $ 209,299 |
| H-42 | CHUK | $ - | $ - | $ - | $ - | $ - | $ - |
| H-43 | Hôpital Ndera (Mental h | $ - | $ - | $ - | $ 23,960 | $ - | $ 23,960 |
| H-44 | KIBUNGO | $ 19,500 | $ 16,000 | $ 11,700 | $ - | $ 120,656 | $ 167,856 |
| H-45 | KIBUYE | $ 19,500 | $ 16,000 | $ 11,700 | $ - | $ 120,656 | $ 167,856 |
| H-46 | King Faysal | $ - | $ - | $ - | $ - | $ - | $ - |
| H-47 | RMH | $ - | $ - | $ - | $ - | $ - | $ - |
| H-48 | RUHENGERI | $ 21,900 | $ 31,500 | $ 8,580 | $ - | $ 96,525 | $ 158,505 |
| H-49 | Gatagara Orthopedic ai | $ - | $ - | $ - | $ 45,746 | $ - | $ 45,746 |
| H-50 | Inkurunziza Orthopedic | $ - | $ - | $ - | $ 14,837 | $ - | $ 14,837 |
| H-51 | Ririma orthopedic Cent | $ - | $ - | $ - | $ 11,024 | $ - | $ 11,024 |
| H-52 | Gatunda | $ - | $ - | $ - | | $ - | $ - |
| H-53 | Kanyinya | $ - | $ - | $ - | | $ - | $ - |
| H-54 | Nyarugenge | $ 21,900 | $ 31,500 | $ 17,160 | | $ 193,049 | $ 263,609 |
| | TOTAL | $ 237.600 | $ 295.000 | $ 143.000 | $ 20.863.492 | $ 1.576.569 | $ 23.115.660 |

| Item | Unit Cost | Unit description | # of units per facility | # facilities | Total units | Total Costs | Remarks |
|---|---|---|---|---|---|---|---|
| Oxygen piping + manifold systems, incl labor costs | $ 2,000 | Bed | 20 | 51 | 1,020 | $ 2,040,000 | Significant oxygen piping system only exists in four secondary or tertiary level hospitals, which makes intra-facility distribution of oxygen very inefficient. We propose to equip all key wards of provincial hospitals, and critical care beds in district hospitals, with an oxygen pipe network (average of 20 beds per hospital) |
| Medical gas cylinder ("J" size), portable, for oxygen, fitted with a valve and a pressure and flow regulator | $ 250 | Cylinder | 215 | 51 | 10,965 | $ 2,741,250 | The recently conducted BME assessment only found 1,455 large cylinder available in Rwanda. We estimate that about 11,000 additional large cylinders are needed to run an efficient delivery system from PSA plants to hospitals (assuming a weekly refill, and high oxygen demand due to COVID) |
| Bubble humidifier, non-heated | $ 4 | Bubble humidifier | 20 | 51 | 1,020 | $ 3,570 | |
| Booster compressor (for cylinder filling) | $ 70,000 | Compressor | 1 | 1 | 1 | $ 70,000 | University Teaching Hospital Of Butare(CHUB)'s PSA plant is currently not in use because it lacks a booster compressor |
| Full maintenance & 2-years of spare parts | $ 50,000 | Lump sum | 1 | 2 | 2 | $ 100,000 | Two PSA plants (1 in Rwinkwavu hospital and 1 in CHUB) need a full maintenance as they are out of order |
| Pulse oximeter - portable handheld, with cables and sensor | $ 317 | Pulse ox | 6 | 51 | 306 | $ 97,002 | |
| BiPAP, with tubing and patient interfaces for adult and paediatric, with accessories | $ 5,204 | BiPAP | 5 | 12 | 60 | $ 312,240 | Only for provincial and referral hospitals that are going to treat the bulk of the critical COVID patients |
| High Flow Nasal Cannula, with tubing and patient interfaces for adult and paediatric, with accessories | $ 4,169 | HFNC device | 5 | 12 | 60 | $ 250,140 | Only for provincial and referral hospitals that are going to treat the bulk of the critical COVID patients |
| Nasal oxygen cannula, with prongs, **adult** | $ 0.22 | Cannula | 25,000 | 51 | 1,275,000 | $ 280,500 | Equivalent to 6-month worth of supplies |
| Nasal oxygen cannula, with prongs, **pediatric** | $ 0.20 | Cannula | 2,500 | 51 | 127,500 | $ 25,500 | Equivalent to 6-month worth of supplies |
| Mask, oxygen, with connection tube, reservoir bag and valve, high-concentration, **adult**, non-sterile, single use | $ 2.92 | Mask | 25,000 | 51 | 1,275,000 | $ 3,723,000 | Equivalent to 6-month worth of supplies |
| Mask, oxygen, with connection tube, reservoir bag and valve, high-concentration, **pediatric**, non-sterile, single use | $ 2.13 | Mask | 2,500 | 51 | 127,500 | $ 271,575 | Equivalent to 6-month worth of supplies |
| Venturi Mask, with percent O2 Lock and tubing, **adult** | $ 1.20 | Venturi mask | 25,000 | 51 | 1,275,000 | $ 1,530,000 | Equivalent to 6-month worth of supplies |
| Venturi Mask, with percent O2 Lock and tubing, **paediatric** | $ 1.20 | Venturi mask | 2,500 | 51 | 127,500 | $ 153,000 | Equivalent to 6-month worth of supplies |
| | | | | | | $ - | |
| | | | | | | $ - | |
| **TOTAL COSTS (ex-works)** | | | | | | **$11,597,777** | |
| Shipping | 10.0% | | | | | | |
| Customs and Tariffs | 0.0% | | | | | | |
| Distribution | 5.0% | | | | | | |
| Installation | 5.0% | | | | | | |
| **TOTAL (estimated landed cost)** | | | | | | **$13,917,332** | |

*Table 3 Rwanda Oxygen Funding requests in key areas*

## Oxygen production and distribution model




**Production split assumption**

| % | Nm3/h |
|---|---|
| 60% | 24 |

| % | Nm3/h | # of large cylinders / day |
|---|---|---|
| 40% | 16 | 56 |

# Rwanda Oxygen PPP project

## CAPEX assumptions

| | | |
|---|---|---|
| Number of sites | 11 | (Number of hospitals with PSA plants) |
| Installed capacity / site | 40 | Nm3 / h |
| Shipping & installation | 30% | |

| Investment costs | Unit cost | # of units | Total | Assumptions |
|---|---|---|---|---|
| ***CAPEX*** | | | | |
| Land Purchase | $ - | 11 | $ - | *Provided at no cost by the hospitals* |
| Civil Works Cost (plant shelter, power connection, etc.) | $ 10,000 | 11 | $ 110,000 | |
| Oxygen pipe network | $ 90,000 | 11 | $ 990,000 | *50 beds on avg to be connected per hospital* |
| Oxygen Plant Purchase Cost | | 11 | $ - | |
| *40 Nm3/h PSA plant* | *$ 92,000* | 11 | $ 1,012,000 | |
| *Cylinder filling station* | *$ 80,000* | 11 | $ 880,000 | |
| *Cylinders Purchase Cost* | *$ 200* | 11000 | $ 2,200,000 | *Assuming 1000 cylinders on avg per site* |
| Oxygen Plant and Cylinders Shipping & Handling Costs | $ 51,660 | 11 | $ 568,260 | |
| Delivery Truck (3.3T) | $ 60,000 | 11 | $ 660,000 | |
| Standby Generator (150kVA) | $ 35,000 | 11 | $ 385,000 | |
| Computers, Fire System and Other Fittings | $ 30,000 | 11 | $ 330,000 | |
| Registration, Licensing and Incorporation Costs | $ 10,000 | 1 | $ 10,000 | |
| **Total CAPEX** | **$ 458,860** | | **$ 7,145,260** | |
| ***Upfront Operational Start-up Costs*** | | | | |
| 4 Months' Working Capital (Operating Expenses) | 302,758 | 11 | $ 3,330,341 | |
| Training Costs | 17,220 | 1 | $ 17,220 | |
| 2 Year Service Kit | 25,000 | 11 | $ 275,000 | |
| **Total Operational Start-Up Costs** | **$ 344,978** | | **$ 3,622,561** | |
| Total Start-Up Costs | $ 803,838 | | $ 10,767,821 | |

| Financing structure | Financing structure % | Cost of capital | Value | Loan duration (years) |
|---|---|---|---|---|
| Debt (concessional rate) | 0% | 7.5% | $ - | 10 |
| Debt (commercial rate) | 75% | 17.0% | $ 8,075,866 | 5 |
| Equity (shareholder return) | 25% | 10.0% | $ 2,691,955 | |
| Grant | 0% | | $ - | |
| **Total** | 100% | | **$ 10,767,821** | |

**Asset depreciation table**

| Description | Purchase Date | Expected Life (Years) | Asset End Date | Unit purchase Price (US$) | Unit purchase Price (RWF) | Straight Line Depreciation (Annual, RWF) |
|---|---|---|---|---|---|---|
| Civil Works Cost (plant shelter, power connection, etc.) | 01/01/2021 | 20 | 27/12/2040 | $ 110,000 | 107,800,000 | 5,390,000 |
| Oxygen pipe network | 01/01/2021 | 20 | 27/12/2040 | $ 990,000 | 970,200,000 | 48,510,000 |
| 40 Nm3/h PSA plant | 01/01/2021 | 20 | 27/12/2040 | $ 1,012,000 | 991,760,000 | 49,588,000 |
| Cylinder filling station | 01/01/2021 | 20 | 27/12/2040 | $ 880,000 | 862,400,000 | 43,120,000 |
| Cylinders Purchase Cost | 01/01/2021 | 20 | 27/12/2040 | $ 2,200,000 | 2,156,000,000 | 107,800,000 |
| Oxygen Plant and Cylinders Shipping & Handling Costs | 01/01/2021 | 20 | 27/12/2040 | $ 568,260 | 556,894,800 | 27,844,740 |
| Delivery Truck (3.3T) | 01/01/2021 | 20 | 27/12/2040 | $ 660,000 | 646,800,000 | 32,340,000 |
| Standby Generator (150kVA) | 01/01/2021 | 20 | 27/12/2040 | $ 385,000 | 377,300,000 | 18,865,000 |
| Computers, Fire System and Other Fittings | 01/01/2021 | 10 | 30/12/2030 | $ 330,000 | 323,400,000 | 32,340,000 |
| TOTAL | | | | | | 365,797,740 |

https://taxsummaries.pwc.com/rwanda/corporate/deductions

Accounting depreciation of fixed assets is not allowable as a deduction for tax purposes. The same applies in the case of amortisation of assets. However, businesses are allowed specified deductions, referred to as tax depreciation in respect of specified classes of assets. This is deducted in arriving at taxable income.

Tax depreciation allowance is granted to persons who own depreciable assets at the end of the tax period and use such assets in the production of income.

Land, fine arts, antiquities, jewellery, and any other assets that are not subject to wear and tear or obsolescence are not depreciated. **Buildings, heavy industrial equipment, and machineries are depreciated annually, each on its own, at a depreciation rate of 5% of the cost of acquisition, construction, refining, rehabilitation, or reconstruction.**

Intangible assets, including goodwill that is purchased from a third party, are depreciated annually, each on its own, at a depreciation rate of 10%, while **information and communication systems whose life is over 10 years are depreciated** annually **at the rate of 10% of the cost of acquisition.**

Computers and accessories and information and communication systems whose life is under 10 years are granted tax depreciation at 50%.

Tax depreciation allowance is available on any other business asset at the rate of 25%.

# Rwanda Oxygen PPP project

## Revenues & OPEX assumptions

**Projection for 11 sites**

| USD/RFW | Inflation (% p.a.) | Production split: Host hospital | Surrounding HF | Price / m3 | Price / cylinder | Cylinder price mark-up | Income tax |
|---|---|---|---|---|---|---|---|
| 980 | 5% | 60% | 40% | 1,294 | 11,000 | 25% | 30% |
| | | | | $ 1.32 | $ 11.22 | | |
| | | | | vs. market price: | -27% | | |

Start date: 01/01/2021

| | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 10-year total | Sources & comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | | |
| **Production Assumptions and Calculations** | | | | | | | | | | | | | |
| **A. Oxygen supplied to host hospital (direct piping)** | | | | | | | | | | | | | |
| Max capacity (Nm3 / h) | 264 | 264 | 264 | 264 | 264 | 264 | 264 | 264 | 264 | 264 | 264 | | |
| Capacity Utilization (%) | 50% | 75% | 80% | 80% | 80% | 80% | 80% | 80% | 80% | 80% | 80% | | |
| Days per month | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | | |
| Total Nm3 of oxygen supplied per year | 1,140,480 | 1,710,720 | 1,824,768 | 1,824,768 | 1,824,768 | 1,824,768 | 1,824,768 | 1,824,768 | 1,824,768 | 1,824,768 | 1,824,768 | 19,274,112 | |
| *In eq. J size cylinder* | *167,718* | *251,576* | *268,348* | *268,348* | *268,348* | *268,348* | *268,348* | *268,348* | *268,348* | *268,348* | *268,348* | 2,834,428 | |
| **B. Oxygen distributed to surrounding health facilities** | | | | | | | | | | | | | |
| Max capacity (max # of cylinders filled per day) | 621 | 621 | 621 | 621 | 621 | 621 | 621 | 621 | 621 | 621 | 621 | | |
| Capacity Utilization (%) | 20% | 40% | 50% | 60% | 70% | 80% | 80% | 80% | 80% | 80% | 80% | | |
| Days per month | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | | |
| Total Number of 6.8m3 Oxygen Cylinders (produced per year) | 29,808 | 59,616 | 74,520 | 89,424 | 104,328 | 119,232 | 119,232 | 119,232 | 119,232 | 119,232 | 119,232 | 1,073,088 | |
| *In eq. M3* | 202,694 | 405,389 | 506,736 | 608,083 | 709,430 | 810,778 | 810,778 | 810,778 | 810,778 | 810,778 | 810,778 | | |
| *Total M3* | 1,343,174 | 2,116,109 | 2,331,504 | 2,432,851 | 2,534,198 | 2,635,546 | 2,635,546 | 2,635,546 | 2,635,546 | 2,635,546 | 2,635,546 | | |
| **Revenue and Taxation Assumptions** | | | | | | | | | | | | | |
| **A. Oxygen supplied to host hospital** | | | | | | | | | | | | | |
| Effective Sales Price per m3 (in RWF) | 1,294 | 1,360 | 1,430 | 1,510 | 1,590 | 1,670 | 1,760 | 1,850 | 1,950 | 2,050 | 2,160 | | |
| **B. Oxygen distributed to surrounding health facilities** | | | | | | | | | | | | | |
| Sales price per cylinder incl. of transportation (in RWF) | 11,000 | 11,550 | 12,130 | 12,740 | 13,380 | 14,050 | 14,760 | 15,500 | 16,280 | 17,100 | 17,960 | | |
| Excise Duty (%) | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | | |
| VAT (%) | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | | Health goods & services are exempted from value added tax (Offi https://taxsummaries.pwc.com/rwanda/corporate/taxes-on-cor |
| Income Tax (%) | 30% | 30% | 30% | 30% | 30% | 30% | 30% | 30% | 30% | 30% | 30% | | |
| Gross Revenue p.a. from host hospital (RWF) | 1,475,915,294 | 2,326,579,200 | 2,609,418,240 | 2,755,399,680 | 2,901,381,120 | 3,047,362,560 | 3,211,591,680 | 3,375,820,800 | 3,558,297,600 | 3,740,774,400 | 3,941,498,880 | | |
| Gross Revenue p.a. from cylinder distribution (RWF) | 327,888,000 | 688,564,800 | 903,927,600 | 1,139,261,760 | 1,395,908,640 | 1,675,209,600 | 1,759,864,320 | 1,848,096,000 | 1,941,096,960 | 2,038,867,200 | 2,141,406,720 | | |
| **Annual Revenue (RWF)** | 1,803,803,294 | 3,015,144,000 | 3,513,345,840 | 3,894,661,440 | 4,297,289,760 | 4,722,572,160 | 4,971,456,000 | 5,223,916,800 | 5,499,394,560 | 5,779,641,600 | 6,082,905,600 | | |
| Annual Revenue (US$) | $ 1,840,616 | $ 3,076,678 | $ 3,585,047 | $ 3,974,144 | $ 4,384,990 | $ 4,818,951 | $ 5,072,914 | $ 5,330,527 | $ 5,611,627 | $ 5,897,593 | $ 6,207,047 | | |
| **Labour Cost Assumptions** | | | | | | | | | | | | | |
| **FTE** | | | | | | | | | | | | | |
| General manager | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | | |
| Biomedical engineer | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | | |
| Biomedical technicians | 22 | 33 | 33 | 33 | 33 | 33 | 33 | 33 | 33 | 33 | 33 | | |
| Cylinder operators | 33 | 55 | 55 | 55 | 55 | 55 | 55 | 55 | 55 | 55 | 55 | | |
| Drivers | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | | |
| Accountants | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | | |
| Sales & procurement officers | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | | |
| **Unit cost (month, gross, RWF)** | | | | | | | | | | | | | |
| General manager | 882,000 | 926,100 | 972,405 | 1,021,025 | 1,072,077 | 1,125,680 | 1,181,964 | 1,241,063 | 1,303,116 | 1,368,271 | 1,436,685 | | |
| Biomedical engineer | 490,000 | 514,500 | 540,225 | 567,236 | 595,598 | 625,378 | 656,647 | 689,479 | 723,953 | 760,151 | 798,158 | | |
| Biomedical technicians | 294,000 | 308,700 | 324,135 | 340,342 | 357,359 | 375,227 | 393,988 | 413,688 | 434,372 | 456,090 | 478,895 | | |
| Cylinder operators | 196,000 | 205,800 | 216,090 | 226,895 | 238,239 | 250,151 | 262,659 | 275,792 | 289,581 | 304,060 | 319,263 | | |
| Drivers | 196,000 | 205,800 | 216,090 | 226,895 | 238,239 | 250,151 | 262,659 | 275,792 | 289,581 | 304,060 | 319,263 | | |
| Accountants | 441,000 | 463,050 | 486,203 | 510,513 | 536,038 | 562,840 | 590,982 | 620,531 | 651,558 | 684,136 | 718,343 | | |
| Sales & procurement officers | 441,000 | 463,050 | 486,203 | 510,513 | 536,038 | 562,840 | 590,982 | 620,531 | 651,558 | 684,136 | 718,343 | | |
| **Total annual staff cost (gross, RWF)** | | | | | | | | | | | | | |
| General manager | 10,584,000 | 11,113,200 | 11,668,860 | 12,252,303 | 12,864,918 | 13,508,164 | 14,183,572 | 14,892,751 | 15,637,388 | 16,419,258 | 17,240,221 | | |
| Biomedical engineer | 17,640,000 | 18,522,000 | 19,448,100 | 20,420,505 | 21,441,530 | 22,513,607 | 23,639,287 | 24,821,251 | 26,062,314 | 27,365,430 | 28,733,701 | | |
| Biomedical technicians | 77,616,000 | 122,245,200 | 128,357,460 | 134,775,333 | 141,514,100 | 148,589,805 | 156,019,295 | 163,820,260 | 172,011,273 | 180,611,836 | 189,642,428 | | |
| Cylinder operators | 77,616,000 | 135,828,000 | 142,619,400 | 149,750,370 | 157,237,889 | 165,099,783 | 173,354,772 | 182,022,511 | 191,123,636 | 200,679,818 | 210,713,809 | | |
| Drivers | 51,744,000 | 54,331,200 | 57,047,760 | 59,900,148 | 62,895,155 | 66,039,913 | 69,341,909 | 72,809,004 | 76,449,454 | 80,271,927 | 84,285,524 | | |
| Accountants | 15,876,000 | 16,669,800 | 17,503,290 | 18,378,455 | 19,297,377 | 20,262,246 | 21,275,358 | 22,339,126 | 23,456,083 | 24,628,887 | 25,860,331 | | |
| Sales & procurement officers | 15,876,000 | 16,669,800 | 17,503,290 | 18,378,455 | 19,297,377 | 20,262,246 | 21,275,358 | 22,339,126 | 23,456,083 | 24,628,887 | 25,860,331 | | |
| **Total Labour Cost (RWF)** | 266,952,000 | 375,379,200 | 394,148,160 | 413,855,568 | 434,548,346 | 456,275,764 | 479,089,552 | 503,044,030 | 528,196,231 | 554,606,043 | 582,336,345 | | |
| Total Labour Cost (US$) | $ 272,400 | $ 383,040 | $ 402,192 | $ 422,302 | $ 443,417 | $ 465,588 | $ 488,867 | $ 513,310 | $ 538,976 | $ 565,925 | $ 594,221 | | |
| **General admin & professional costs** | | | | | | | | | | | | | |
| Office rental | 5,880,000 | 6,174,000 | 6,482,700 | 6,806,835 | 7,147,177 | 7,504,536 | 7,879,762 | 8,273,750 | 8,687,438 | 9,121,810 | 9,577,900 | | |
| Other general admin and professional costs (1% of sales) | $ 18,038,033 | $ 30,151,440 | $ 35,133,458 | $ 38,946,614 | $ 42,972,898 | $ 47,225,722 | $ 49,714,560 | $ 52,239,168 | $ 54,993,946 | $ 57,796,416 | $ 60,829,056 | | |
| **Total G&A cost (RWF)** | 23,918,033 | 36,325,440 | 41,616,158 | 45,753,449 | 50,120,074 | 54,730,257 | 57,594,322 | 60,512,918 | 63,681,384 | 66,918,226 | 70,406,956 | | |
| Total G&A cost (US$) | $ 24,406 | $ 37,067 | $ 42,465 | $ 46,687 | $ 51,143 | $ 55,847 | $ 58,770 | $ 61,748 | $ 64,981 | $ 68,284 | $ 71,844 | | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Plants repair & maintenance costs** | | | | | | | | | | | |
| Spare parts & maintenance cost (after the 2 y initial warranty) | | | 53,900,000 | 56,595,000 | 59,424,750 | 62,395,988 | 65,515,787 | 68,791,576 | 72,231,155 | 75,842,713 | 79,634,848 |
| Spare parts & maintenance cost (US$) | $ - | $ - | $ 55,000 | $ 57,750 | $ 60,638 | $ 63,669 | $ 66,853 | $ 70,195 | $ 73,705 | $ 77,391 | $ 81,260 |
| **Electricity Cost Assumptions** | | | | | | | | | | | |
| | Cost per kwh | Kwh (plant) | Kwh (filling) | Service charge/ month | | Energy price factor | | | | | |
| | 122 | 80 | 25 | 10,000 | | 100% | | | | | |
| Annual Electricity Cost - oxygen plant | 463,366,464 | 729,109,181 | 816,505,262 | 857,330,526 | 900,197,052 | 945,206,904 | 992,467,250 | 1,042,090,612 | 1,094,195,143 | 1,148,904,900 | 1,206,350,145 |
| Annual Electricity Cost - filling station | 38,503,872 | 80,858,131 | 106,126,297 | 133,719,134 | 163,805,940 | 196,567,128 | 206,395,484 | 216,715,258 | 227,551,021 | 238,928,572 | 250,875,001 |
| **Total electrictiy costs (RWF)** | **501,870,336** | **809,967,312** | **922,631,560** | **991,049,660** | **1,064,002,992** | **1,141,774,032** | **1,198,862,734** | **1,258,805,870** | **1,321,746,164** | **1,387,833,472** | **1,457,225,146** |
| **Total electricity cost (US$)** | $ 512,113 | $ 826,497 | $ 941,461 | $ 1,011,275 | $ 1,085,717 | $ 1,165,076 | $ 1,223,329 | $ 1,284,496 | $ 1,348,721 | $ 1,416,157 | $ 1,486,964 |
| **Transportation Costs** | | | | | | | | | | | |
| Fuel and Transport Costs | 39,619,008 | 83,199,917 | 109,199,891 | 137,591,862 | 168,550,031 | 202,260,038 | 212,373,040 | 222,991,692 | 234,141,276 | 245,848,340 | 258,140,757 |
| Vehicle Repair and Maintenance Costs | 57,750,000 | 57,750,000 | 60,637,500 | 63,669,375 | 66,852,844 | 70,195,486 | 73,705,260 | 77,390,523 | 81,260,049 | 85,323,052 | 89,589,204 |
| **Total Fuel & Transportation Costs p.a. (RWF)** | **97,369,008** | **140,949,917** | **169,837,391** | **201,261,237** | **235,402,875** | **272,455,524** | **286,078,300** | **300,382,215** | **315,401,326** | **331,171,392** | **347,729,961** |
| **Total Fuel & Transportation Costs p.a. (US$)** | $ 99,356 | $ 143,826 | $ 173,303 | $ 205,369 | $ 240,207 | $ 278,016 | $ 291,917 | $ 306,512 | $ 321,838 | $ 337,930 | $ 354,826 |
| **Financing cost assumptions** | | | | | | | | | | | |
| *Financing parameters can be adjusted in the CAPEX inputs tab* | | | | | | | | | | | |
| Commercial loan interest payment (US$) | $ 1,188,308 | $ 1,100,804 | $ 860,335 | $ 575,645 | $ 238,603 | $ 2,804 | $ - | $ - | $ - | $ - | $ - - |
| Concessional loan interest repayment (US$) | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - | $ - |

https://www.reg.rw/customer-service/tariffs/
Industrial tariff category (medium size business)

| Fuel cost calc for one site | | Cost per km (RWF) |
|---|---|---|
| Delivery days / y | 312 | Diesel cost (L) |
| Avg km travelled / d | 150 | Consumption |
| Total km travelled / y | 46,800 | |
| | - | Cost per Km |

**Vehicule repair & maintenance**
5,000,000 per truck / year

# Rwanda Oxygen PPP project

## Financial Projections

**Projection for 11 sites**

| | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 6 | Year 7 | Year 8 | Year 9 | Year 10 | Year 11 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 10 y Total | 10 y Total (abs.) |
| Gross Revenue p.a. from host hospital | 1,475,915,294 | 2,326,579,200 | 2,609,418,240 | 2,755,399,680 | 2,901,381,120 | 3,047,362,560 | 3,211,591,680 | 3,375,820,800 | 3,558,297,600 | 3,740,774,400 | 3,941,498,880 | 29,002,540,574 | 29,002,540,574 |
| Gross Revenue p.a. from cylinder distribution | 327,888,000 | 688,564,800 | 903,927,600 | 1,139,261,760 | 1,395,908,640 | 1,675,209,600 | 1,759,864,320 | 1,848,096,000 | 1,941,096,960 | 2,038,867,200 | 2,141,406,720 | 13,718,684,880 | 13,718,684,880 |
| **Net Revenue p.a.** | **1,803,803,294** | **3,015,144,000** | **3,513,345,840** | **3,894,661,440** | **4,297,289,760** | **4,722,572,160** | **4,971,456,000** | **5,223,916,800** | **5,499,394,560** | **5,779,641,600** | **6,082,905,600** | 42,721,225,454 | 42,721,225,454 |
| - Electricity Costs | -501,870,336 | -809,967,312 | -922,631,560 | -991,049,660 | -1,064,002,992 | -1,141,774,032 | -1,198,862,734 | -1,258,805,870 | -1,321,746,164 | -1,387,833,472 | -1,457,225,146 | - 10,598,544,132 | 10,598,544,132 |
| - Repair & maintenance costs | 0 | 0 | -53,900,000 | -56,595,000 | -59,424,750 | -62,395,988 | -65,515,787 | -68,791,576 | -72,231,155 | -75,842,713 | -79,634,848 | - 514,696,968 | 514,696,968 |
| - Labour Costs - Production | -183,456,000 | -287,708,400 | -302,093,820 | -317,198,511 | -333,058,437 | -349,711,358 | -367,196,926 | -385,556,773 | -404,834,611 | -425,076,342 | -446,330,159 | - 3,355,891,178 | 3,355,891,178 |
| **Gross Profit** | **1,118,476,958** | **1,917,468,288** | **2,234,720,460** | **2,529,818,269** | **2,840,803,582** | **3,168,690,782** | **3,339,880,553** | **3,510,762,581** | **3,700,582,630** | **3,890,889,073** | **4,099,715,447** | 28,252,093,176 | 28,252,093,176 |
| *Gross Profit Margin* | *62%* | *64%* | *64%* | *65%* | *66%* | *67%* | *67%* | *67%* | *67%* | *67%* | *67%* | *66%* | |
| - Labour Costs - Sales, Distribution & Admin | -83,496,000 | -87,670,800 | -92,054,340 | -96,657,057 | -101,489,910 | -106,564,405 | -111,892,626 | -117,487,257 | -123,361,620 | -129,529,701 | -136,006,186 | - 1,050,203,715 | 1,050,203,715 |
| - O2 transportation Costs | -97,369,008 | -140,949,917 | -169,837,391 | -201,261,237 | -235,402,875 | -272,455,524 | -286,078,300 | -300,382,215 | -315,401,326 | -331,171,392 | -347,729,961 | - 2,350,309,184 | 2,350,309,184 |
| - Selling, General Admin and Professional Costs | -23,918,033 | -36,325,440 | -41,616,158 | -45,753,449 | -50,120,074 | -54,730,257 | -57,594,322 | -60,512,918 | -63,681,384 | -66,918,226 | -70,406,956 | - 501,170,263 | 501,170,263 |
| **EBITDA** | **913,693,917** | **1,652,522,131** | **1,931,212,571** | **2,186,146,525** | **2,453,790,722** | **2,734,940,596** | **2,884,315,305** | **3,032,380,190** | **3,198,138,301** | **3,363,269,755** | **3,545,572,343** | 24,350,410,014 | 24,350,410,014 |
| *EBITDA Margin* | *51%* | *55%* | *55%* | *56%* | *57%* | *58%* | *58%* | *58%* | *58%* | *58%* | *58%* | *57%* | |
| - Loan interest repayment | -1,164,542,118 | -1,078,787,993 | -843,127,914 | -564,131,897 | -233,830,820 | -2,747,546 | 0 | 0 | 0 | 0 | 0 | - 3,887,168,287 | 3,887,168,287 |
| - Asset depreciation | -365,797,740 | -365,797,740 | -365,797,740 | -365,797,740 | -365,797,740 | -365,797,740 | -365,797,740 | -365,797,740 | -365,797,740 | -365,797,740 | -365,797,740 | - 3,657,977,400 | 3,657,977,400 |
| **EBT** | **(616,645,941)** | **207,936,399** | **722,286,917** | **1,256,216,888** | **1,854,162,163** | **2,366,395,310** | **2,518,517,565** | **2,666,582,450** | **2,832,340,561** | **2,997,472,015** | **3,179,774,603** | 16,805,264,327 | 16,805,264,327 |
| - Income Tax | 0 | 0 | -216,686,075 | -376,865,066 | -556,248,649 | -709,918,593 | -755,555,270 | -799,974,735 | -849,702,168 | -899,241,604 | -953,932,381 | - 5,164,192,161 | 5,164,192,161 |
| **Net Income/Loss** | **(616,645,941)** | **207,936,399** | **505,600,842** | **879,351,822** | **1,297,913,514** | **1,656,476,717** | **1,762,962,296** | **1,866,607,715** | **1,982,638,393** | **2,098,230,410** | **2,225,842,222** | 11,641,072,166 | 11,641,072,166 |
| *Net Income Margin* | *-34%* | *7%* | *14%* | *23%* | *30%* | *35%* | *35%* | *36%* | *36%* | *36%* | *37%* | *27%* | |
| + Asset depreciation | 365,797,740 | 365,797,740 | 365,797,740 | 365,797,740 | 365,797,740 | 365,797,740 | 365,797,740 | 365,797,740 | 365,797,740 | 365,797,740 | 365,797,740 | 3,657,977,400 | 3,657,977,400 |
| + Investor's equity | 2,638,116,196 | | | | | | | | | | | 2,638,116,196 | 2,638,116,196 |
| + Loan receipt | 7,914,348,587 | | | | | | | | | | | 7,914,348,587 | 7,914,348,587 |
| + Grant receipt | 0 | | | | | | | | | | | - | - |
| - Capital expenditure | -10,552,464,782 | | | | | | | | | | | - 10,552,464,782 | 10,552,464,782 |
| - Loan principal repayment | -999,069,309 | -1,281,515,382 | -1,517,175,460 | -1,796,171,478 | -2,126,472,555 | -193,944,402 | 0 | 0 | 0 | 0 | 0 | - 7,914,348,587 | 7,914,348,587 |
| - Shareholder dividends | 0 | 0 | 0 | 0 | 0 | -263,811,620 | -263,811,620 | -263,811,620 | -263,811,620 | -263,811,620 | -263,811,620 | - 1,319,058,098 | 1,319,058,098 |
| **Free cash flow (RWF)** | **(1,249,917,510)** | **(707,781,244)** | **(645,776,879)** | **(551,021,916)** | **(462,761,301)** | **1,564,518,435** | **1,864,948,416** | **1,968,593,836** | **2,084,624,513** | **2,200,216,531** | **2,327,828,343** | 6,065,642,882 | 6,065,642,882 |
| Free cash flow (US$) | (1,275,426) | (722,226) | (658,956) | (562,267) | (472,205) | 1,596,447 | 1,903,009 | 2,008,769 | 2,127,168 | 2,245,119 | 2,375,335 | | |

# Rwanda Oxygen PPP project

## Financial Projections

**Projection for 11 sites**

| in RWF unless otherwise stated | Year 1<br>2021 | Year 2<br>2022 | Year 3<br>2023 | Year 4<br>2024 | Year 5<br>2025 | Year 6<br>2026 | Year 7<br>2027 | Year 8<br>2028 | Year 9<br>2029 |
|---|---|---|---|---|---|---|---|---|---|
| Gross Revenue p.a. from host hospital | 1,475,915,294 | 2,326,579,200 | 2,609,418,240 | 2,755,399,680 | 2,901,381,120 | 3,047,362,560 | 3,211,591,680 | 3,375,820,800 | 3,558,297,600 |
| Gross Revenue p.a. from cylinder distribution | 327,888,000 | 688,564,800 | 903,927,600 | 1,139,261,760 | 1,395,908,640 | 1,675,209,600 | 1,759,864,320 | 1,848,096,000 | 1,941,096,960 |
| **Net Revenue p.a.** | **1,803,803,294** | **3,015,144,000** | **3,513,345,840** | **3,894,661,440** | **4,297,289,760** | **4,722,572,160** | **4,971,456,000** | **5,223,916,800** | **5,499,394,560** |
| | | | | | | | | | |
| - Electricity Costs | -501,870,336 | -809,967,312 | -922,631,560 | -991,049,660 | -1,064,002,992 | -1,141,774,032 | -1,198,862,734 | -1,258,805,870 | -1,321,746,164 |
| - Repair & maintenance costs | 0 | 0 | -53,900,000 | -56,595,000 | -59,424,750 | -62,395,988 | -65,515,787 | -68,791,576 | -72,231,155 |
| - Labour Costs - Production | -183,456,000 | -287,708,400 | -302,093,820 | -317,198,511 | -333,058,437 | -349,711,358 | -367,196,926 | -385,556,773 | -404,834,611 |
| **Gross Profit** | **1,118,476,958** | **1,917,468,288** | **2,234,720,460** | **2,529,818,269** | **2,840,803,582** | **3,168,690,782** | **3,339,880,553** | **3,510,762,581** | **3,700,582,630** |
| *Gross Profit Margin* | *62%* | *64%* | *64%* | *65%* | *66%* | *67%* | *67%* | *67%* | *67%* |
| | | | | | | | | | |
| - Labour Costs - Sales, Distribution & Admin | -83,496,000 | -87,670,800 | -92,054,340 | -96,657,057 | -101,489,910 | -106,564,405 | -111,892,626 | -117,487,257 | -123,361,620 |
| - O2 transportation Costs | -97,369,008 | -140,949,917 | -169,837,391 | -201,261,237 | -235,402,875 | -272,455,524 | -286,078,300 | -300,382,215 | -315,401,326 |
| - Selling, General Admin and Professional Costs | -23,918,033 | -36,325,440 | -41,616,158 | -45,753,449 | -50,120,074 | -54,730,257 | -57,594,322 | -60,512,918 | -63,681,384 |
| **EBITDA** | **913,693,917** | **1,652,522,131** | **1,931,212,571** | **2,186,146,525** | **2,453,790,722** | **2,734,940,596** | **2,884,315,305** | **3,032,380,190** | **3,198,138,301** |
| *EBITDA Margin* | *51%* | *55%* | *55%* | *56%* | *57%* | *58%* | *58%* | *58%* | *58%* |
| | | | | | | | | | |
| - Loan interest repayment | -1,164,542,118 | -1,078,787,993 | -843,127,914 | -564,131,897 | -233,830,820 | -2,747,546 | 0 | 0 | 0 |
| - Asset depreciation | -365,797,740 | -365,797,740 | -365,797,740 | -365,797,740 | -365,797,740 | -365,797,740 | -365,797,740 | -365,797,740 | -365,797,740 |
| | | | | | | | | | |
| **EBT** | **(616,645,941)** | **207,936,399** | **722,286,917** | **1,256,216,888** | **1,854,162,163** | **2,366,395,310** | **2,518,517,565** | **2,666,582,450** | **2,832,340,561** |
| | | | | | | | | | |
| - Income Tax | 0 | 0 | -216,686,075 | -376,865,066 | -556,248,649 | -709,918,593 | -755,555,270 | -799,974,735 | -849,702,168 |
| | | | | | | | | | |
| **Net Income/Loss** | **(616,645,941)** | **207,936,399** | **505,600,842** | **879,351,822** | **1,297,913,514** | **1,656,476,717** | **1,762,962,296** | **1,866,607,715** | **1,982,638,393** |
| *Net Income Margin* | *-34%* | *7%* | *14%* | *23%* | *30%* | *35%* | *35%* | *36%* | *36%* |
| | | | | | | | | | |
| + Asset depreciation | 365,797,740 | 365,797,740 | 365,797,740 | 365,797,740 | 365,797,740 | 365,797,740 | 365,797,740 | 365,797,740 | 365,797,740 |
| + Investor's equity | 2,638,116,196 | | | | | | | | |
| + Loan receipt | 7,914,348,587 | | | | | | | | |
| + Grant receipt | 0 | | | | | | | | |
| - Capital expenditure | -10,552,464,782 | | | | | | | | |
| - Loan principal repayment | -999,069,309 | -1,281,515,382 | -1,517,175,460 | -1,796,171,478 | -2,126,472,555 | -193,944,402 | 0 | 0 | 0 |
| - Shareholder dividends | 0 | 0 | 0 | 0 | 0 | -263,811,620 | -263,811,620 | -263,811,620 | -263,811,620 |
| | | | | | | | | | |
| **Free cash flow (RWF)** | **(1,249,917,510)** | **(707,781,244)** | **(645,776,879)** | **(551,021,916)** | **(462,761,301)** | **1,564,518,435** | **1,864,948,416** | **1,968,593,836** | **2,084,624,513** |
| Free cash flow (US$) | (1,275,426) | (722,226) | (658,956) | (562,267) | (472,205) | 1,596,447 | 1,903,009 | 2,008,769 | 2,127,168 |

**A) Financing structure & selling price**

| Financing structure | Financing structure % | Cost of capital |
|---|---|---|
| Debt (concessional rate) | 50% | 7.5% |
| Debt (commercial rate) | 25% | 17.0% |
| Equity (shareholder return) | 25% | 10.0% |
| Philantropic grant | 0% | |

| Cylinder price | Diff. vs. current market price | 10 y NPV (US$) | IRR (%) |
|---|---|---|---|
| 7000 | -53% | $ -974,145 | -23% |
| 8000 | -47% | $ -252,595 | 3% |
| 9000 | -40% | $ 400,406 | 24% |
| 10000 | -33% | $ 947,236 | 43% |
| 11000 | -27% | $ 1,544,959 | 73% |
| 12000 | -20% | $ 2,271,336 | 183% |
| 13000 | -13% | $ 2,949,398 | 1564% |
| 14000 | -7% | $ 3,538,924 | 437% |
| 15000 | 0% | $ 4,232,645 | 4614% |

| Financing structure | Financing structure % | Cost of capital |
|---|---|---|
| Debt (concessional rate) | 0% | 7.5% |
| Debt (commercial rate) | 75% | 17.0% |
| Equity (shareholder return) | 25% | 10.0% |
| Philantropic grant | 0% | |

| Cylinder price | Diff vs current market price | 10 y NPV (US$) | IRR (%) |
|---|---|---|---|
| 7000 | -53% | $ -1,469,818 | -9% |
| 8000 | -47% | $ -888,356 | 0% |
| 9000 | -40% | $ -266,677 | 10% |
| 10000 | -33% | $ 256,258 | 20% |
| 11000 | -27% | $ 831,727 | 32% |
| 12000 | -20% | $ 1,274,600 | 43% |
| 13000 | -13% | $ 1,769,171 | 59% |
| 14000 | -7% | $ 2,248,308 | 78% |
| 15000 | 0% | $ 2,803,082 | 119% |

| Financing structure | Financing structure % | Cost of capital |
|---|---|---|
| Debt (concessional rate) | 0% | 7.5% |
| Debt (commercial rate) | 50% | 17.0% |
| Equity (shareholder return) | 50% | |
| Philantropic grant | 0% | |

| Cylinder price | Diff vs current market price | 10 y NPV (US$) | IRR (%) |
|---|---|---|---|
| 7000 | -53% | $ -952,310 | -22% |
| 8000 | -47% | $ -454,048 | -2% |
| 9000 | -40% | $ -135,547 | 12% |
| 10000 | -33% | $ -108,215 | 15% |
| 11000 | -27% | $ 78,300 | 21% |
| 12000 | -20% | $ 585,997 | 40% |
| 13000 | -13% | $ 1,056,450 | 71% |
| 14000 | -7% | $ 1,181,696 | 50% |
| 15000 | 0% | $ 1,663,594 | 70% |

| Energy price | 100% |
|---|---|
| Price | 11000 |

| NPV | IRR |
|---|---|
| $ 535,449 | 19.1% |

| | | |
|---|---|---|
| 10000 | $ | 10.20 |
| 12000 | $ | 12.24 |

**B) Energy price & selling price**

10 Y NPV (US$)

| Cylinder price (RWF) | Energy price (var. vs. base scenario) -20% | 0% | +20% | +40% |
|---|---|---|---|---|
| 8000 | $ -507,636 | $ -888,356 | $ -1,282,518 | $ -1,670,697 |
| 10000 | $ 652,740 | $ 256,258 | $ -107,705 | $ -475,587 |
| 11000 | $ 1,120,566 | $ 831,727 | $ 435,245 | $ 80,379 |
| 12000 | $ 1,588,872 | $ 1,274,600 | $ 1,005,089 | $ 658,995 |
| 14000 | $ 2,616,520 | $ 2,248,308 | $ 1,950,815 | $ 1,569,749 |

IRR

| Cylinder price (RWF) | Energy price -20% | 0% | +20% | +40% |
|---|---|---|---|---|
| 8000 | 6% | 0% | -6% | -11% |
| 10000 | 29% | 20% | 13% | 7% |
| | 40% | 32% | 23% | 17% |
| 12000 | 54% | 43% | 36% | 28% |
| 14000 | 107% | 78% | 65% | 49% |

# Rwanda Oxygen PPP project

## CAPEX assumptions

| | | |
|---|---|---|
| Number of sites | 11 | (Number of hospitals with PSA plants) |
| Installed capacity / site | 40 | Nm3 / h |
| Shipping & installation | 30% | |

| Investment costs | | Unit cost | # of units | | Total | Assumptions |
|---|---|---|---|---|---|---|
| ***CAPEX*** | | | | | | |
| Land Purchase | $ | - | 11 | $ | - | *Provided at no cost by the hospitals* |
| Civil Works Cost (plant shelter, power connection, etc.) | $ | 10,000 | 11 | $ | 110,000 | |
| Oxygen pipe network | $ | 90,000 | 11 | $ | 990,000 | *50 beds on avg to be connected per hospital* |
| Oxygen Plant Purchase Cost | | | 11 | $ | - | |
| *40 Nm3/h PSA plant* | $ | *92,000* | 11 | $ | 1,012,000 | |
| *Cylinder filling station* | $ | *80,000* | 11 | $ | 880,000 | |
| *Cylinders Purchase Cost* | $ | *200* | 11000 | $ | 2,200,000 | *Assuming 1000 cylinders on avg per site* |
| Oxygen Plant and Cylinders Shipping & Handling Costs | $ | 51,660 | 11 | $ | 568,260 | |
| Delivery Truck (3.3T) | $ | 60,000 | 11 | $ | 660,000 | |
| Standby Generator (150kVA) | $ | 35,000 | 11 | $ | 385,000 | |
| Computers, Fire System and Other Fittings | $ | 30,000 | 11 | $ | 330,000 | |
| Registration, Licensing and Incorporation Costs | $ | 10,000 | 1 | $ | 10,000 | |
| **Total CAPEX** | **$** | **458,860** | | **$** | **7,145,260** | |
| | | | | | | |
| ***Upfront Operational Start-up Costs*** | | | | | | |
| 4 Months' Working Capital (Operating Expenses) | | 302,758 | 11 | $ | 3,330,341 | |
| Training Costs | | 17,220 | 1 | $ | 17,220 | |
| 2 Year Service Kit | | 25,000 | 11 | $ | 275,000 | |
| **Total Operational Start-Up Costs** | **$** | **344,978** | | **$** | **3,622,561** | |
| | | | | | | |
| **Total Start-Up Costs** | **$** | **803,838** | | **$** | **10,767,821** | |

| Financing structure | Financing structure % | Cost of capital | | Value | Loan duration (years) |
|---|---|---|---|---|---|
| Debt (concessional rate) | 0% | 7.5% | $ | - | 10 |
| Debt (commercial rate) | 75% | 17.0% | $ | 8,075,866 | 5 |
| Equity (shareholder return) | 25% | 10.0% | $ | 2,691,955 | |
| Grant | 0% | | $ | - | |
| **Total** | **100%** | | **$** | **10,767,821** | |

**Asset depreciation table**

| Description | Purchase Date | Expected Life (Years) | Asset End Date | | Unit purchase Price (US$) | Unit purchase Price (RWF) | Straight Line Depreciation (Annual, RWF) |
|---|---|---|---|---|---|---|---|
| Civil Works Cost (plant shelter, power connection, etc.) | 01/01/2021 | 20 | 27/12/2040 | $ | 110,000 | 107,800,000 | 5,390,000 |
| Oxygen pipe network | 01/01/2021 | 20 | 27/12/2040 | $ | 990,000 | 970,200,000 | 48,510,000 |
| 40 Nm3/h PSA plant | 01/01/2021 | 20 | 27/12/2040 | $ | 1,012,000 | 991,760,000 | 49,588,000 |
| Cylinder filling station | 01/01/2021 | 20 | 27/12/2040 | $ | 880,000 | 862,400,000 | 43,120,000 |
| Cylinders Purchase Cost | 01/01/2021 | 20 | 27/12/2040 | $ | 2,200,000 | 2,156,000,000 | 107,800,000 |
| Oxygen Plant and Cylinders Shipping & Handling Costs | 01/01/2021 | 20 | 27/12/2040 | $ | 568,260 | 556,894,800 | 27,844,740 |
| Delivery Truck (3.3T) | 01/01/2021 | 20 | 27/12/2040 | $ | 660,000 | 646,800,000 | 32,340,000 |
| Standby Generator (150kVA) | 01/01/2021 | 20 | 27/12/2040 | $ | 385,000 | 377,300,000 | 18,865,000 |
| Computers, Fire System and Other Fittings | 01/01/2021 | 10 | 30/12/2030 | $ | 330,000 | 323,400,000 | 32,340,000 |
| **TOTAL** | | | | | | | **365,797,740** |

https://taxsummaries.pwc.com/rwanda/corporate/deductions

Accounting depreciation of fixed assets is not allowable as a deduction for tax purposes. The same applies in the case of amortisation of assets. However, businesses are allowed specified deductions, referred to as tax depreciation in respect of specified classes of assets. This is deducted in arriving at taxable income.

Tax depreciation allowance is granted to persons who own depreciable assets at the end of the tax period and use such assets in the production of income.

Land, fine arts, antiquities, jewellery, and any other assets that are not subject to wear and tear or obsolescence are not depreciated. **Buildings, heavy industrial equipment, and machineries are depreciated annually, each on its own, at a depreciation rate of 5% of the cost of acquisition, construction, refining, rehabilitation, or reconstruction.**

Intangible assets, including goodwill that is purchased from a third party, are depreciated annually, each on its own, at a depreciation rate of 10%, while **information and communication systems whose life is over 10 years are depreciated annually at the rate of 10% of the cost of acquisition.**

Computers and accessories and information and communication systems whose life is under 10 years are granted tax depreciation at 50%.

Tax depreciation allowance is available on any other business asset at the rate of 25%.

# Commercial Loan reimbursment table

| | |
|---|---|
| Loan amount | $ 8,075,866 |
| Interest rate | 17.00% |
| Loan duration (years) | 5 |
| Starting date | 01/01/2021 |
| Monthly payment | $ 200,706 |
| Annual payment | $ 2,408,473 |
| Number of payments (months) | 60 |
| Interest paid (total) | $ 3,966,498 |
| Total cost of the loan | $ 12,042,364 |

| Start | 01/01/2021 | 01/01/2022 | 01/01/2023 | 01/01/2024 | 01/01/2025 | 01/01/2026 | 01/01/2027 | 01/01/2028 | 01/01/2029 | 01/01/2030 | 01/01/2031 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| end | 31/12/2021 | 31/12/2022 | 31/12/2023 | 31/12/2024 | 31/12/2025 | 31/12/2026 | 31/12/2027 | 31/12/2028 | 31/12/2029 | 31/12/2030 | 31/12/2031 |
| | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 |
| Capital | 1,019,458 | 1,307,669 | 1,548,138 | 1,832,828 | 2,169,870 | 197,902 | - | - | - | - | - |
| Interest | 1,188,308 | 1,100,804 | 860,335 | 575,645 | 238,603 | 2,804 | - | - | - | - | - |
| Payment | 2,207,767 | 2,408,473 | 2,408,473 | 2,408,473 | 2,408,473 | 200,706 | - | - | - | - | - |
| Check | - | - | - | - | - | - | - | - | - | - | - |

| N° | Payment Date | Opening balance | Payment | Capital | Interest | Ending balance |
|---|---|---|---|---|---|---|
| 1 | 01/02/2021 | 8,075,865.90 € | 200,706.07 € | 86,297.97 € | 114,408.10 € | 7,989,567.94 € |
| 2 | 01/03/2021 | 7,989,567.94 € | 200,706.07 € | 87,520.52 € | 113,185.55 € | 7,902,047.41 € |
| 3 | 01/04/2021 | 7,902,047.41 € | 200,706.07 € | 88,760.40 € | 111,945.67 € | 7,813,287.01 € |
| 4 | 01/05/2021 | 7,813,287.01 € | 200,706.07 € | 90,017.84 € | 110,688.23 € | 7,723,269.18 € |
| 5 | 01/06/2021 | 7,723,269.18 € | 200,706.07 € | 91,293.09 € | 109,412.98 € | 7,631,976.09 € |
| 6 | 01/07/2021 | 7,631,976.09 € | 200,706.07 € | 92,586.41 € | 108,119.66 € | 7,539,389.68 € |
| 7 | 01/08/2021 | 7,539,389.68 € | 200,706.07 € | 93,898.05 € | 106,808.02 € | 7,445,491.63 € |
| 8 | 01/09/2021 | 7,445,491.63 € | 200,706.07 € | 95,228.27 € | 105,477.80 € | 7,350,263.36 € |
| 9 | 01/10/2021 | 7,350,263.36 € | 200,706.07 € | 96,577.34 € | 104,128.73 € | 7,253,686.02 € |
| 10 | 01/11/2021 | 7,253,686.02 € | 200,706.07 € | 97,945.52 € | 102,760.55 € | 7,155,740.51 € |
| 11 | 01/12/2021 | 7,155,740.51 € | 200,706.07 € | 99,333.08 € | 101,372.99 € | 7,056,407.43 € |
| 12 | 01/01/2022 | 7,056,407.43 € | 200,706.07 € | 100,740.30 € | 99,965.77 € | 6,955,667.13 € |
| 13 | 01/02/2022 | 6,955,667.13 € | 200,706.07 € | 102,167.45 € | 98,538.62 € | 6,853,499.68 € |
| 14 | 01/03/2022 | 6,853,499.68 € | 200,706.07 € | 103,614.82 € | 97,091.25 € | 6,749,884.85 € |
| 15 | 01/04/2022 | 6,749,884.85 € | 200,706.07 € | 105,082.70 € | 95,623.37 € | 6,644,802.15 € |
| 16 | 01/05/2022 | 6,644,802.15 € | 200,706.07 € | 106,571.37 € | 94,134.70 € | 6,538,230.78 € |
| 17 | 01/06/2022 | 6,538,230.78 € | 200,706.07 € | 108,081.13 € | 92,624.94 € | 6,430,149.65 € |
| 18 | 01/07/2022 | 6,430,149.65 € | 200,706.07 € | 109,612.28 € | 91,093.79 € | 6,320,537.36 € |
| 19 | 01/08/2022 | 6,320,537.36 € | 200,706.07 € | 111,165.12 € | 89,540.95 € | 6,209,372.24 € |
| 20 | 01/09/2022 | 6,209,372.24 € | 200,706.07 € | 112,739.96 € | 87,966.11 € | 6,096,632.28 € |
| 21 | 01/10/2022 | 6,096,632.28 € | 200,706.07 € | 114,337.11 € | 86,368.96 € | 5,982,295.17 € |
| 22 | 01/11/2022 | 5,982,295.17 € | 200,706.07 € | 115,956.89 € | 84,749.18 € | 5,866,338.28 € |
| 23 | 01/12/2022 | 5,866,338.28 € | 200,706.07 € | 117,599.61 € | 83,106.46 € | 5,748,738.67 € |
| 24 | 01/01/2023 | 5,748,738.67 € | 200,706.07 € | 119,265.60 € | 81,440.46 € | 5,629,473.06 € |
| 25 | 01/02/2023 | 5,629,473.06 € | 200,706.07 € | 120,955.20 € | 79,750.87 € | 5,508,517.86 € |
| 26 | 01/03/2023 | 5,508,517.86 € | 200,706.07 € | 122,668.73 € | 78,037.34 € | 5,385,849.13 € |
| 27 | 01/04/2023 | 5,385,849.13 € | 200,706.07 € | 124,406.54 € | 76,299.53 € | 5,261,442.59 € |
| 28 | 01/05/2023 | 5,261,442.59 € | 200,706.07 € | 126,168.97 € | 74,537.10 € | 5,135,273.62 € |
| 29 | 01/06/2023 | 5,135,273.62 € | 200,706.07 € | 127,956.36 € | 72,749.71 € | 5,007,317.27 € |
| 30 | 01/07/2023 | 5,007,317.27 € | 200,706.07 € | 129,769.07 € | 70,936.99 € | 4,877,548.19 € |
| 31 | 01/08/2023 | 4,877,548.19 € | 200,706.07 € | 131,607.47 € | 69,098.60 € | 4,745,940.72 € |
| 32 | 01/09/2023 | 4,745,940.72 € | 200,706.07 € | 133,471.91 € | 67,234.16 € | 4,612,468.81 € |
| 33 | 01/10/2023 | 4,612,468.81 € | 200,706.07 € | 135,362.76 € | 65,343.31 € | 4,477,106.05 € |
| 34 | 01/11/2023 | 4,477,106.05 € | 200,706.07 € | 137,280.40 € | 63,425.67 € | 4,339,825.65 € |
| 35 | 01/12/2023 | 4,339,825.65 € | 200,706.07 € | 139,225.21 € | 61,480.86 € | 4,200,600.44 € |
| 36 | 01/01/2024 | 4,200,600.44 € | 200,706.07 € | 141,197.56 € | 59,508.51 € | 4,059,402.88 € |
| 37 | 01/02/2024 | 4,059,402.88 € | 200,706.07 € | 143,197.86 € | 57,508.21 € | 3,916,205.02 € |
| 38 | 01/03/2024 | 3,916,205.02 € | 200,706.07 € | 145,226.50 € | 55,479.57 € | 3,770,978.52 € |
| 39 | 01/04/2024 | 3,770,978.52 € | 200,706.07 € | 147,283.87 € | 53,422.20 € | 3,623,694.65 € |
| 40 | 01/05/2024 | 3,623,694.65 € | 200,706.07 € | 149,370.40 € | 51,335.67 € | 3,474,324.25 € |
| 41 | 01/06/2024 | 3,474,324.25 € | 200,706.07 € | 151,486.48 € | 49,219.59 € | 3,322,837.78 € |
| 42 | 01/07/2024 | 3,322,837.78 € | 200,706.07 € | 153,632.53 € | 47,073.54 € | 3,169,205.24 € |
| 43 | 01/08/2024 | 3,169,205.24 € | 200,706.07 € | 155,809.00 € | 44,897.07 € | 3,013,396.25 € |
| 44 | 01/09/2024 | 3,013,396.25 € | 200,706.07 € | 158,016.29 € | 42,689.78 € | 2,855,379.96 € |
| 45 | 01/10/2024 | 2,855,379.96 € | 200,706.07 € | 160,254.85 € | 40,451.22 € | 2,695,125.11 € |
| 46 | 01/11/2024 | 2,695,125.11 € | 200,706.07 € | 162,525.13 € | 38,180.94 € | 2,532,599.98 € |
| 47 | 01/12/2024 | 2,532,599.98 € | 200,706.07 € | 164,827.57 € | 35,878.50 € | 2,367,772.41 € |
| 48 | 01/01/2025 | 2,367,772.41 € | 200,706.07 € | 167,162.63 € | 33,543.44 € | 2,200,609.78 € |
| 49 | 01/02/2025 | 2,200,609.78 € | 200,706.07 € | 169,530.76 € | 31,175.31 € | 2,031,079.01 € |
| 50 | 01/03/2025 | 2,031,079.01 € | 200,706.07 € | 171,932.45 € | 28,773.62 € | 1,859,146.56 € |
| 51 | 01/04/2025 | 1,859,146.56 € | 200,706.07 € | 174,368.16 € | 26,337.91 € | 1,684,778.41 € |
| 52 | 01/05/2025 | 1,684,778.41 € | 200,706.07 € | 176,838.38 € | 23,867.69 € | 1,507,940.03 € |
| 53 | 01/06/2025 | 1,507,940.03 € | 200,706.07 € | 179,343.59 € | 21,362.48 € | 1,328,596.44 € |
| 54 | 01/07/2025 | 1,328,596.44 € | 200,706.07 € | 181,884.29 € | 18,821.78 € | 1,146,712.16 € |
| 55 | 01/08/2025 | 1,146,712.16 € | 200,706.07 € | 184,460.98 € | 16,245.09 € | 962,251.18 € |
| 56 | 01/09/2025 | 962,251.18 € | 200,706.07 € | 187,074.18 € | 13,631.89 € | 775,177.00 € |

## Concessional Loan reimbursment table

| | |
|---|---|
| Loan amount | $ - |
| Interest rate | 7.50% |
| Loan duration (years) | 10 |
| Starting date | 01/01/2021 |
| | |
| Monthly payment | |
| Annual payment | #VALUE! |
| Number of payments (months) | |
| Interest paid (total) | |
| Total cost of the loan | |

| N° | Payment Date | Opening balance | Payment | Capital | Interest | ending balance |
|---|---|---|---|---|---|---|

| start | 01/01/2021 | 01/01/2022 | 01/01/2023 | 01/01/2024 | 01/01/2025 | 01/01/2026 | 01/01/2027 | 01/01/2028 | 01/01/2029 | 01/01/2030 | 01/01/2031 | 01/01/2032 | 01/01/2033 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| end | 31/12/2021 | 31/12/2022 | 31/12/2023 | 31/12/2024 | 31/12/2025 | 31/12/2026 | 31/12/2027 | 31/12/2028 | 31/12/2029 | 31/12/2030 | 31/12/2031 | 31/12/2032 | 31/12/2033 |
| | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 2033 |
| Capital | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Interest | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Payment | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Check | - | - | - | - | - | - | - | - | - | - | - | - | - |

| facility_name | average number of consumed per week | Total cylinder cost / week | Average price per liquid liter in RWF | Average price per large cylinder in RWF | Average price per large cylinder in USD |
|---|---|---|---|---|---|
| BUSHENGE | 1250 | 500000 | 400 | 20,000 | $ 20.41 |
| BYUMBA | 5250 | 1785000 | 340 | 17,000 | $ 17.35 |
| CHUB | 12250 | 3675000 | 300 | 15,000 | $ 15.31 |
| CHUK | 4500 | 1350000 | 300 | 15,000 | $ 15.31 |
| GAHINI | 1050 | 346500 | 330 | 16,500 | $ 16.84 |
| GAKOMA | 70 | 21000 | 300 | 15,000 | $ 15.31 |
| Gatagara Orthopedic and Rehabilitation Hospital | 20 | 6000 | 300 | 15,000 | $ 15.31 |
| GISENYI | 3000 | 750000 | 250 | 12,500 | $ 12.76 |
| GITWE | 400 | 170000 | 425 | 21,250 | $ 21.68 |
| Inkurunziza Orthopedic Hospital | 150 | 70000 | 467 | 23,333 | $ 23.81 |
| KABAYA | 200 | 50000 | 250 | 12,500 | $ 12.76 |
| KABGAYI | 2967 | 735919 | 248 | 12,402 | $ 12.65 |
| KABUTARE | 1066 | 320000 | 300 | 15,009 | $ 15.32 |
| KACYIRU | 1750 | 420000 | 240 | 12,000 | $ 12.24 |
| KADUHA | 7 | 2100 | 300 | 15,000 | $ 15.31 |
| KIBAGABAGA | 5250 | 1312500 | 250 | 12,500 | $ 12.76 |
| KIBILIZI | 200 | 60000 | 300 | 15,000 | $ 15.31 |
| KIBOGORA | 100 | 60000 | 600 | 30,000 | $ 30.61 |
| KIBUNGO | 1347 | 404100 | 300 | 15,000 | $ 15.31 |
| KIBUYE | 2050 | 615000 | 300 | 15,000 | $ 15.31 |
| KIGEME | 300 | 90000 | 300 | 15,000 | $ 15.31 |
| KINIHIRA | 2500 | 850000 | 340 | 17,000 | $ 17.35 |
| KIRINDA | 400 | 135000 | 338 | 16,875 | $ 17.22 |
| KIZIGURO | 1670 | 567800 | 340 | 17,000 | $ 17.35 |
| MASAKA | 5600 | 1568000 | 280 | 14,000 | $ 14.29 |
| MIBIRIZI | 120 | 60000 | 500 | 25,000 | $ 25.51 |
| MUGONERO | 200 | 70000 | 350 | 17,500 | $ 17.86 |
| MUHIMA | 4500 | 1260000 | 280 | 14,000 | $ 14.29 |
| MUHORORO | 600 | 150000 | 250 | 12,500 | $ 12.76 |
| MUNINI | 550 | 165000 | 300 | 15,000 | $ 15.31 |
| MURUNDA | 1000 | 250000 | 250 | 12,500 | $ 12.76 |
| NEMBA | 500 | 125000 | 250 | 12,500 | $ 12.76 |
| NGARAMA | 1250 | 375000 | 300 | 15,000 | $ 15.31 |
| NYAMATA | 3500 | 980000 | 280 | 14,000 | $ 14.29 |
| NYANZA | 450 | 150000 | 333 | 16,667 | $ 17.01 |
| REMERA RUKOMA | 1000 | 300000 | 300 | 15,000 | $ 15.31 |
| Ririma orthopedic Center | 25 | 11500 | 460 | 23,000 | $ 23.47 |
| RUHANGO | 625 | 218750 | 350 | 17,500 | $ 17.86 |
| RUHENGERI | 5600 | 1400000 | 250 | 12,500 | $ 12.76 |
| RULI | 500 | 150000 | 300 | 15,000 | $ 15.31 |
| RUTONGO | 500 | 150000 | 300 | 15,000 | $ 15.31 |
| RWAMAGANA | 5040 | 1260000 | 250 | 12,500 | $ 12.76 |
| RWINKWAVU | 2983 | 745833 | 250 | 12,501 | $ 12.76 |
| SHYIRA | 700 | 210000 | 300 | 15,000 | $ 15.31 |
| | | | | RWF | USD |
| Average | | | 317 | 15,853 | 16.18 |
| Min | | | 240 | 12,000 | $ 12.24 |
| Max | | | 600 | 30,000 | $ 30.61 |

12000
13625.3478
15000

| | | | | | | |
|---|---|---|---|---|---|---|
| Quartile 25% | 13,625 | $ | 13.90 | 12000 | 13625.3478 | 15000 |
| Median | 15,000 | $ | 15.31 | | | |
| Quartile 75% | 16,906 | $ | 17.25 | | | |
| | 1 | | | | | |
| | 44 | | | | | |
| | 0.022727273 | | | | | |