SAMS

Policy document

Oxygen availability for Covid-19 management in North West Syria

October 21, 2021

Background

Under-resourced settings have faced inequitable access to essential medicines, vaccines, and resources during the COVID-19 pandemic, including medical oxygen. In countries affected by protracted conflict, where health systems are already strained and resources depleted, the impact of such shortages are magnified. One such context is northwest Syria where, in an area of 3,460 square meters[i], 4.2 million civilians, half of whom are internally displaced persons (IDPs), face not only a second surge of COVID-19 cases but also ongoing hostilities and continued attacks on health facilities. Other challenges include fuel and electricity shortages, lack of experienced maintenance for oxygen generators and the long and always delayed supply chain for spare parts and supplies affecting COVID-19 treatment centres, which also impact oxygen delivery.

Medical oxygen is lifesaving in the treatment of COVID-19, however there remains a technology and training gap in its provision in many under-resourced countries. The main oxygen sources in northwest Syria are PSA (pressure swing operation) oxygen plants, which provide 91-96% oxygen and can either be piped

Key messages

- **We found a 34% gap in medical oxygen at the current occupancy rate, which equals (5,976 m3/Day), and a 50% gap at full occupancy rate (10,173 m3/Day).**
- **To address the full gap, health actors will need to provide 21 additional oxygen generators (20 m3/h capacity) in the hospital based isolation units and COVID-19 community treatment centers.**
- **It is recommended to buy 3,798 additional oxygen cylinders for the COVID-19 facilities if relying on the cylinders to close the operational gap, with enough maneuverability to cover.**
- **For short-term planning, there is a need to increase engagement and cooperation with Turkish authorities to secure the needed approvals to export liquid oxygen to NWS.**
- **In order to address the short-term needs, donors must mobilize resources to purchase liquid oxygen as the cheapest and the fastest way to solve the oxygen deficit. An amount of 60 m3 of LOx. is sufficient to close the gap for 9 days for all NWS COVID-19 facilities, and for 5 days at a 100% consumption rate.**
- **More assessments are needed to fully understand the needs for oxygen in the northern area of Aleppo Governorate.**
- **Long-term oxygen resource planning should be considered beyond COVID-19 treatment.**

directly to the bedside or used to refill cylinders for oxygen distribution (either on on-site or to neighboring health facilities); oxygen cylinders which are used despite presenting logistical challenges due primarily to their limited oxygen storage capacity; and electricity powered oxygen concentrators which produce an oxygen purity of 80-90% with flow rates of only 1-5 L/minute. Despite the latter being intended mainly for the use of home oxygen, the absence of electricity in many homes means that most concentrators are mainly situated in health facilities.

COVID-19 SITUATION AT A GLANCE

The first peak of COVID-19 cases in Northwest Syria was in November 2020, thereafter steadily increasing to the point where we are facing a severe second wave alongside an increase in hostilities including against healthcare facilities. As of 17th October 2021, 76,967 cases have been confirmed with 1,016 cases declared on the 3rd October 2021 alone. The rate of positive tests amongst the samples tested has reached 61% as the pandemic continues spreading amid the vulnerable IDP population, with 1,130 cases confirmed in tented settlements. 98% of the new confirmed cases are of the Delta variant which is more infectious than previous variants and for which vaccines are less effective in prevention.

A significant increase in mortality has also been noted, as 1,407 deaths have been attributed to COVID-19 in Northwest Syria as of 17th October, 2021. Between May 1st 2021 and October 2nd 2021, 529 COVID-19 deaths were recorded, amongst those deaths only 7 were partially or fully vaccinated. As such, 2.9% of the population of NW Syria have received one dose of the vaccine to date, and only 0.84% have received both doses. COVID-19 health facilities are overwhelmed with patients as 36,021 cases have required inpatient care in a COVID-19 treatment facility (HBIUs (hospitals based isolation centers) or CCTCs (COVID-19 community treatment center), of which only 2,137 had access to specialist care in a COVID-19 designated hospital. 61% of beds in COVID-19 CCTCs are occupied to date, and five out of the nine isolation units are at or over capacity. This is in addition to ventilators in ICU units in the HBIUs being in use at 98% capacity.

OBJECTIVE

This policy document aims to:

1. Quantify the extent of oxygen shortages and issues that affect oxygen supply during the current wave of the COVID-19 pandemic, in the fragile humanitarian setup of northwest Syria;
2. To provide recommendations on how different stakeholders can address the gap in oxygen production in both the short and long term.

An information gathering framework was designed to collect information that focused on the following categories related to oxygen production and delivery:

- Available assets and production capacity
- Current consumption
- Gap size
- Costs
- Logistical hurdles
- Solutions

METHODS

A mixture of quantitative and qualitative data was collected for this policy document. The quantitative secondary data was collected from multiple sources including the WHO COVID-19 response and tracking dashboard in northwest Syria[ii]; daily and weekly occupancy rate updates issued by the Ministry of Health of the Syrian Interim Government (MoH SIG); COVID-19 cumulative reports

from the Health Information System Unit of local health directorates and assessments of oxygen assets collected by the Idlib Health Directorate [iii] (IHD) for both hospitals based isolation centers (HBIUs) and the Covid-19 community treatment centers (CCTCs).

Primary data regarding the medical and logistical challenges, as well as the suggested solutions, was collected through informal discussions with key stakeholders including those working with IHD, managers at COVID-19 treatment facilities, private oxygen suppliers, ICU doctors and ICU technicians focused on oxygen consumptions of patients in the centers, other technicians and logistic officers that are engaged with the oxygen supply chain.
In addition to this, one focus group discussion with leaders from health NGOs, conducted by IHD on September 18th, was also very useful in discussing the challenges and ways to avoid the collapse of the health system in the face of the current wave.

Limitations

The main challenges faced upon collating the data and completing the study were:

1. Difficulties in accessing enough information about COVID-19 facilities and oxygen resources in Aleppo governorate.
2. Various fluctuations in oxygen production numbers throughout the last two months due to different repairs and maintenance rounds.
3. Flow rates utilized in different hospitals or medical facilities have the potential of differing and therefore we settled on an average usage.

Results

Table 1 provides an overview of the health facilities with information on oxygen shortages, numbers of patients and capacity. It shows the number of available generators, concentrators, and cylinders. As per our capacities, the number of cylinders has increased from **533** cylinders in May 2021 to **939** in October 2021, and the number of concentrators also increased from **82** to **197**. Interviewed doctors and technicians reported that improvement in oxygen saturation levels in patients using concentrators happened only when two concentrators were linked together to provide a flow of 10 L/min per patient.

Facility name	NGO	No. Generators	Production capacity m3/h	No. Concentrators	No. Oxygen cylinders
Mare hospital	AHD	1	20	0	NA
Alsham Isolation Hospital	SHAM	2	36	19	100
Alamal Isolation Hospital	SAMS	3	51	29	100
Alziraa Isolation Hospital	SAMS	3	51	33	128
Salqin Isolation Hospital	SAMS	3	51	30	100
Avicenna pediatric hospital	SAMS	0	0	5	66
Carlton Isolation Hospital	SEMA	1	48	21	80
Jisr Al Shogour Hospital	SEMA	1	12	15	85
Kafartakhareem Hospital	SEMA	1	48	25	90
National hospital	MSF	1	20	15	100
Salqin Isolation Hospital II	MSF	1	10	5	90
		17	**347**	**197**	**939**

Table 1 Available oxygen generation assets in the HBIUs

Oxygen assets

Covid-19 isolation hospitals

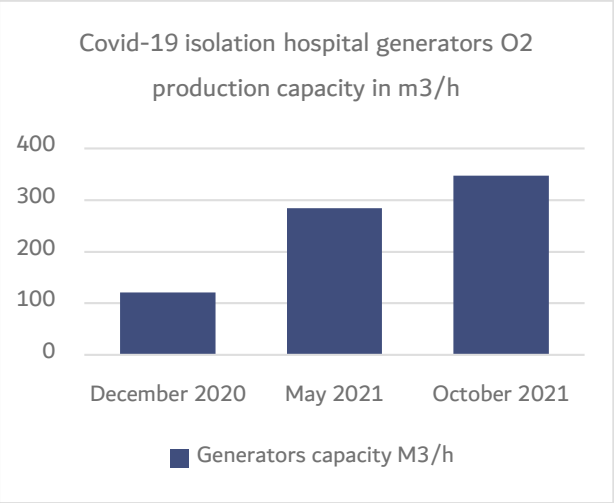

Figure 1 Comparative O2 Production rate in the HBIUs between December 2020 and October 2021

All partners have scaled up their oxygen generation capacity in their COVID-19 facilities since the first wave of the pandemic arrived in northwest Syria. Production has increased between May 2021 and October 2021 from 284 m3/h to 347 m3/h.
At least three hospitals (run by SAMS) have scaled up one more generator each. However, while the overall capacity has been increased, the individual capacity of each generator has decreased. The reasons for this decline could be attributed to technical issues after long hours of non-stop running for these generators, oxygen operators have to compromise flow rate to maintain a 90% purity rate.

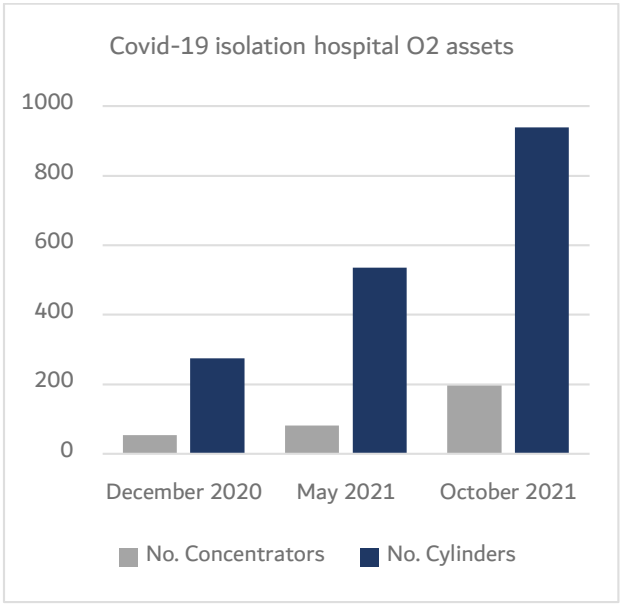

Figure 2 Oxygen assets in HBIUs

Covid-19 Community treatment centers (CCTCs)

After the closure of many CCTCs (some of them due to financial limitations while others due to lack of therapeutic benefit), only 15 CCTCs are currently available out of the 33 centers that were opened at the beginning of the pandemic. The number of concentrators has remained relatively constant compared to May (**228** versus **234**), but the challenge is that not all the centers are capable of running these concentrators for financial or technical problems. The total number of working concentrators is now **215**. The number of cylinders has increased slightly from **296** to **358**

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Code	CCTC Name	Number of Cylinders	Number of Concentrators	Total beds
CCTC_33	Afrin	58	3	30
CCTC_35	Al-Bab 02	40	9	25
CCTC_03	Atareb	15	10	50
CCTC_07	Daret Azza 01	10	20	100
CCTC_05	Hazano	20	30	50
CCTC_26	Ma'arrat Tamasrin 02	10	16	50
CCTC_36	Mare'	50	17	50
CCTC_02	Armanaz	16	20	35
CCTC_28	Atma	20	18	40
CCTC_04	Dana	20	13	40
CCTC_30	Kafar Karmeen	20	10	50
CCTC_25	Sarmada	20	16	30
CCTC_01	Ariha	11	8	100
CCTC_16	Idleb city	1	15	45
CCTC_34	Al-Bab 01	17	10	85
CCTC_21	Ma'arrat Tamasrin 01	30	19	50
Total		**358**	**234**	**830**

Table 2 Available oxygen assets in the CCTCs

Other health facilities

Humanitarian hospitals

In Idlib governorate, **20** NGO-run non-COVID-19 hospitals have oxygen production capacities with a total production capacity estimated at **249** m3/h. As it stands, **89** oxygen concentrators were counted in these health facilities and the total number of available cylinders is **1042**. These numbers declined by **50**% in comparison with the assessment that was conducted in May 2021, after IHD had verified the actual production capacities and removed duplications in the database.

Private hospitals

The capacity of the private sector to generate oxygen in the area is limited out of 17 facilities, as reported by IHD. Only **two** hospitals have small oxygen generators with a total capacity of **15** m3/h. Most of these hospitals rely on external oxygen suppliers for their work.

Oxygen consumption rates and gap size

In the previous assessment conducted in May 2021, we calibrated consumption rates per patient according to WHO's recommendations[iv]. However, interviewed doctors and ICU technicians interviewed in the field, told us that they adapted these numbers according to medical observations to improve the prognosis. The main difference comes from the increase of oxygen intake for patients with non-invasive ventilation (NIV) using BiPAP and CPAP devices from 25 L/min to 70 L/min. The current ratio of NIV patients in the ICU unit versus the number of intubated patients on ventilators is 19% compared to 81% on NIV. Moreover, the average length of stay for each patient has increased from **3.9** days in November 2020 (first peak) to **6.6** days in September 2021 in hospitals wards, and from **5.3** to **9.3** days in the ICUs.

	Old assumptions	Current application
Low flow rates in CCTCs	5 L/min	5 L/min
Low flow rates in hospital wards	Not included before	10 L/min
Non-invasive ventilation (NIV) using CPAP	7 L/min	**25 L/D**
Non-invasive ventilation (NIV) using BiPAP	10 L/min	**50 L/D**
Invasive ventilation devices and intubation	10 L/min	**7.75 L/D**

Table 3 calibrated oxygen consumption as per treatment modality based on the field doctors practice

Based on the recent admission ratios and occupation rates that are shared by MoH-SIG, we have reached a total of 87% occupancy rate at the HBIUs wards and 93% rate at the ICUs. The gap in production represents **29%** of the total need (**4,003 m3/D or 1,001 cylinder/Day).** This gap will increase to **41%** at a 100% occupancy rate if we maintain the current admission ratio of BiPAP patients at 81% in the ICUs **(5,918 m3/D or 1,479 cylinder/Day).** Non-invasively ventilated patients are by far the biggest consumers of oxygen resources in the hospitals for the time being.

When asking doctors if they can intubate their patients to economize in oxygen instead of putting them on BiPAP, one challenge faced here is the lack of sufficient medications necessary to perform the intubation procedure. In addition to this, an important thing to note is that recent data suggests that prognosis for patients managed with NIV is better than invasive ventilation.

#	Hospital name	ward oxygen consumption m3/D	ICU oxygen consumption m3/D	Total consumption m3/D	Total Production in m3/D	GAP in m3/d as per admission
1	Mare hospital	144.00	847.80	991.80	480.0	-511.8
2	Alsham Hospital	432.00	1556.64	1988.64	1000.8	-987.84
3	Alamal Hospital	576.00	1819.80	2395.80	1432.8	-963
4	Alziraa Hospital	547.20	1626.12	2173.32	1461.6	-711.72
5	Salqin Hospital	576.00	1650.96	2226.96	1440.0	-786.96
6	Avicenna hospital	72.00	0.00	72.00	36.0	-36
7	Carlton Hospital	532.80	828.00	1360.80	1303.2	-57.6
8	Jisr Al Shogour Hospital	288.00	166.32	454.32	396.0	-58.32
9	Kafrtakhareem Hospital	590.40	645.48	1235.88	1332.0	96.12
10	National hospital	432.00	0.00	432.00	588.0	156
11	Salqin hospital II	417.60	0.00	417.60	276.0	-141.6
	Total	**4608.00**	**9141.12**	**13749.12**	**9746**	**-4002.72**

Table 4 Consumption rate and GAP size in the HBIUs (as per 10/10/2021)

In the CCTCs, the current occupancy rate has reached 69%. The present oxygen gap is estimated at 38% (1973 m3/D or 493 cylinder/Day). Currently provided by external oxygen suppliers, this gap will increase to 72% at full occupancy rate for these centers.

#	Code	Concentrators O2 production m3/D	Oxygen need in m3/D	Oxygen GAP in m3/D as per admission
1	CCTC_33	21.6	187	-165.6
2	CCTC_35	64.8	137	-72.0
3	CCTC_03	72	274	-201.6
4	CCTC_07	144	353	-208.8
5	CCTC_05	216	360	-144.0
6	CCTC_26	115.2	230	-115.2
7	CCTC_36	122.4	115	7.2
8	CCTC_02	144	209	-64.8
9	CCTC_28	72	245	-172.8
10	CCTC_04	129.6	230	-100.8
11	CCTC_30	115.2	223	-108.0
12	CCTC_25	93.6	173	-79.2
13	CCTC_01	57.6	202	-144.0
14	CCTC_16	136.8	288	-151.2
15	CCTC_34	108	216	-108.0
16	CCTC_21	72	216	-144.0
	Total	**1684.8**	**3657.6**	**-1972.8**

Table 5Consumption rate and GAP size in the CCTCs (as per 10/10/2021)

In total, the current oxygen deficit for all facilities combined is estimated at **34%** of the overall production, equaling **5,976 m3/D** or **1,494 cylinders** per day), and **50%** at full occupancy rate, especially for the CCTCs that equal 10,173 **m3/D** or **2,543 cylinders** per day).

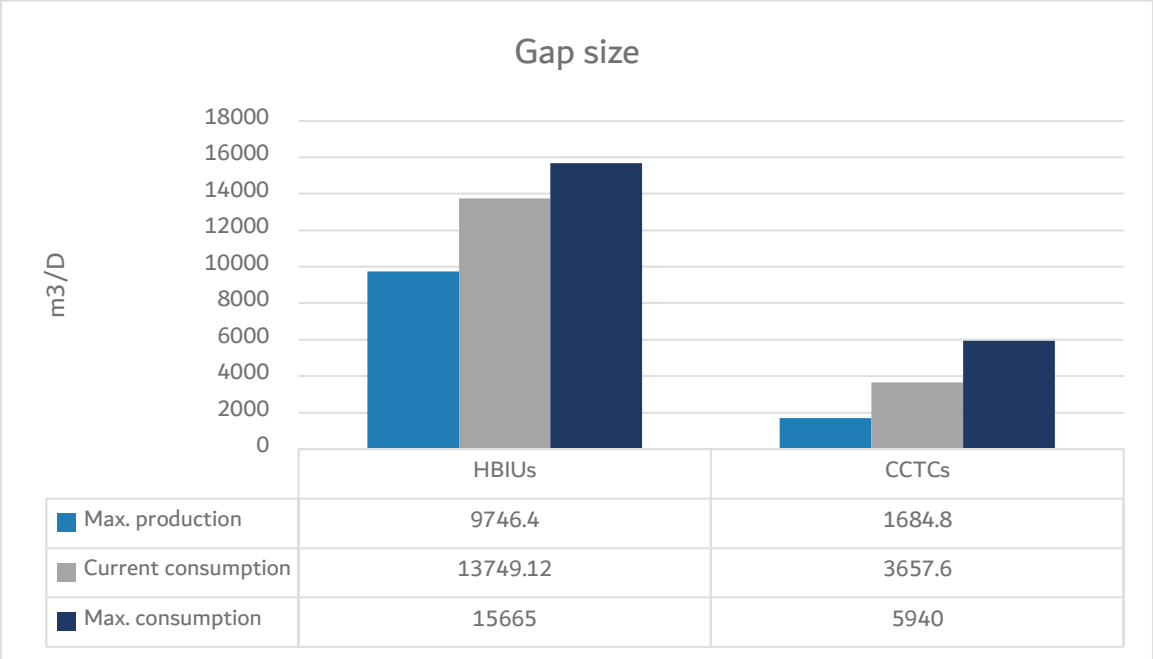

Table 6 Gap size estimate versus production and current and max. consumption rates

COSTS

Costs of filling oxygen

Based on the current gap in production and the average price for filling oxygen cylinders in the private sector in northwest Syria are estimated at ~5.6 USD per cylinder, this estimate does not include the many indirect costs of transportation and oxygen station workers.

	M3/D	Cylinders	Daily cost	Monthly cost
Current Gap	5,976	1,494	**8,365 USD**	**250,951 USD**
Max. Gap	10,173	2,543	**14,241 USD**	**427,258 USD**

Table 7 Cost of filling oxygen cylinders (100 Bar, 4000 L)

Costs of procuring oxygen generators

Prices of oxygen generators were based on the average purchase prices that were made in May 2020 for PSA generators, at 20 m3/h. The cost varied according to the country of origin and capacity. The price of a generator was found to be cheaper the more it was in higher capacity, as associated with the increased risk of oxygen shortage in case of shut-down for any reason.

These PSA generators require regular maintenance and replacement of their inner granules (zeolite granules or membranes utilized to separate the oxygen from carbon dioxide in the air), which makes them less efficient in the long term. Moreover, we are not taking into consideration technical errors that might force the generators to stop working for days or weeks, affecting the overall production.

	M3/D	generators for HBIUs	generators for CCTCs	Price in USD
Current Gap	5,976	8	4	**771,838 USD**
Max. Gap	10,173	12	9	**1,314,093 USD**

Table 8 Cost of procuring additional oxygen generators

Costs of procuring new oxygen cylinders

The interviewed logistics personnel have highlighted that even if they get cylinders that are enough to fill oxygen at the daily consumption rates, there is still a high risk of having transfer bottlenecks when sending the cylinders back and forth between the hospitals and suppliers. The risk increases the longer the distance gets between the two locations. Another such risk is that on days where there are ongoing clashes, the transportation could be impacted for several hours and thus delaying receiving the supplies on time. As such, it was highly recommended that each center should have two times the amount of needed cylinders in possession (1x in the hospital as a contingency, 0.5x on the road, and 0.5x with the supplier.)

	Available cylinders in both HBIUs and CCTCs	Cylinders needed with 0 contingency	Price in USD	Cylinders needed with 2X contingency	Price in USD
Current Gap	1,297	197	**28,762 USD**	1,691	**246,886 USD**
Max. Gap		1246	**181,916 USD**	3,798	**533,194 USD**

Table 9 Cost of procuring additional oxygen cylinders

Logistical hurdles

Lack of experienced maintenance teams

Oxygen generators require regular maintenance rounds by experienced teams to keep them at an optimal status. Unfortunately, we are unable to bring maintenance teams from the manufacturers due to the access restraints from the ongoing conflict. There is a great need to train local engineers and maintenance technicians on the different errors and malfunctions that the generators face regularly, and equip them with the necessary tools and equipment to run their diagnosis.

Lack of spare parts

Due to the conflict, whenever a certain part needs replacement, it could take up to two months to procure a replacement. Procurement policies within the NGOs are partially responsible for these delays, in the case that there isn't enough budget to anticipate spare parts in the first place.

Transportation issues

Roadways in northwest Syria are in bad conditions after years of conflict and lack of rehabilitation and rebuilding projects. The daily transfer of heavy oxygen cylinders is a big logistical challenge for all hospitals in case roads are closed for any reason or in the case of an accident involving a transportation truck; such incidents put the facility at risk of running out of oxygen.

Limited numbers of oxygen cylinder

The small number of available oxygen cylinders means that currently no hospital can send out more than ~25% of its overall cylinders, on a single trip, to the supplier to keep up with the oxygen need in the hospitals.

Limitation of private suppliers

Currently, all Covid-19 facilities are receiving their needed oxygen from local private vendors, which are incredibly outstretched within themselves and can barely cover the demand. They are facing increasing pressure from non-Covid-19 hospitals, private hospitals, and home-based patients who are also trying to purchase oxygen cylinders. Not only is their ability to cover the demand affected, but also, the price could rise with the increasing demand: the highest price achieved was 7 USD/cylinder, compared to the 5.6 USD at the present moment.

Challenges and Solutions

For many of those interviewed, as well as those who participated in group discussions, it was clear that closing the current gap is essential to avoid the collapse of the existing health system. This is important to keep the minimal COVID-19 case management services ongoing, as well as to keep the morale of the health staff who struggle day and night to keep the patients alive. The main outcomes of the discussions were:

- There is still an ongoing **funding problem**, as the oxygen gap has been identified since December 2020, and yet without the

success in securing funding for this equipment.

- **Procurement and logistical hurdles** remain such that even if we get all the requested funds to purchase the conventional oxygen equipment that we need, it will take at least three months to get them to northwest Syria. This is problematic as we are in need of oxygen t right now.
- **Programmatic challenges** are particularly acute in situations where oxygen generators were purchased in the previous wave to address COVID-19 cases but were distributed to facilities that do not provide COVID-19 treatment. Despite efforts to relocate these generators, it has not been possible until now. In addition to this, there are not enough operational costs to run these generators where they are presently located and establishing an oxygen bridge between these facilities and COVID-19 facilities via an oxygen cylinders' transfer is not easy due to the limited number of available oxygen cylinders.

To address these challenges, the group has come out with various recommendations:

- Rapidly **advocate for additional funding** to address the oxygen gap in particular, and for the overall funding gap for the COVID response in general.
- It is important to think about **immediate short-term solutions** to cover the current need and **long-term solutions** to avoid having an oxygen deficit in the future.
- It is important for local health authorities to guide and **coordinate programming** to avoid having important assets out of usage in the future.

While thinking about the short-term solutions, one in particular is striking, and it is: the utilization of **Liquid Oxygen**. Liquid oxygen has a density of (1.141 kg/L or 1141 kg/m3), and a boiling point of 90.19 K (−182.96 °C; −297.33 °F) at a standard atmosphere. Liquid oxygen has an expansion ratio of **1:798 under 1 standard atmosphere (100 kPa) and 0 °C**, or 1:861 under 1 standard atmosphere (100 kPa) and 20 °C.
This expansion capacity is interesting because it means that we can store Liquid oxygen at **a much smaller volume.** Furthermore, liquid oxygen can be delivered by cryogenic tankers into northwest Syria and stored in vacuum-insulated storage vessels that are associated with vaporizer equipment, and which could provide supply for several days.
Therefore, the existing gap at the current occupancy rate of 5,976 m3 gas oxygen/Day equals **6.8 m3 of LOx**. Whilst the gap at 100% occupancy rate **of 9,867 m3** oxygen gas/day equals **11.6 m3 of LOx,** providing liquid oxygen with reasonable storage capacity (1 tank of 60 m3 tank for example) would provide a supply that is sufficient for **8.8** days of all of northwest Syria's Covid HBICs and CCTCs deficiency needs at the current consumption rate, and for **5.17 days** at a 100% consumption rate.
The initial market survey indicates that the average LOx price in Turkey is at **0.34 USD/ liquid oxygen litre (340 USD/ 1 ton),** which means that we still have a large saving margin in procuring, being **3.29 times cheaper.**
This reflects the price of the economy by using liquid oxygen to close the gap, and the anticipated cost in case we reach full capacity. We will be saving approximately 3,944 **USD every day** if we opt for liquid oxygen, or **118,320 USD per month**.

Description	Daily gap m3 gas	Monthly cost for Gas oxygen	Monthly cost for liquid oxygen	Difference in USD
Current gap	5,976	**250,951 USD**	**69,360 USD**	**181,591 USD**
Max. gap	10,173	**427,258 USD**	**118,320 USD**	**308,932 USD**

Table 10 Difference in price between liquid and non-liquid oxygen

Such price difference will help to procure the initial installation requirement for the liquid oxygen (the storage vessel which could reach up to **200,000 USD for the 60 m3** size). This cost is paid only once, and the vessel thereafter will be used as a fixed asset for the area.

Limits of using liquid oxygen

Exportation restriction

Turkish **customs restrict the exportation** of Liquid oxygen abroad, and thus to have approval we need to send a request to the Ministry of Health, who will provide the necessary customs permissions.

Safety considerations

According to DOT/ TDG classification, liquid oxygen is considered as a non-flammable gas with subsidiary risk (Oxidizer). Its oxidizing power can greatly accelerate the burning rate for both common and exotic combustible materials. Emergency personnel must practice extreme caution when approaching oxygen releases because of the potential for intense fire. There is a risk if used near a facility, especially if targeted with airstrikes or other forms of weaponry. Therefore, it is better to establish a station near the border and not at the facility.

Storage

As mentioned earlier, liquid oxygen is stored in **special containers or vessels** that could be expensive, it is therefore better to have a central station with vaporization equipment to fill oxygen cylinders according to the need.

Conclusion

Based on the current analysis that covers HBICs and CCTCs needs, it is clear that WHO and health partners responding to COVID-19 in northwest Syria should think about solutions to ensure providing Oxygen to their health facilities. A rapid solution should be available in both the short and long term. It is recommended that health partners work on procuring enough quantities of oxygen generation and transportation solutions to cover the current gap. Solutions include purchasing more PSA oxygen plants, oxygen cylinders, and/or opt for the provision of Liquid oxygen from Turkey. Each solution has its advantages and disadvantages that have been detailed in the brief above.

Finally, oxygen resource planning should be anticipated to cover the needs in northwest Syria for medical oxygen that goes beyond COVID-19 care, as oxygen is essential to provide care for patients at all levels in the healthcare system, including surgery, trauma, heart failure, asthma, pneumonia and maternal and child care. It is necessary to ensure local needs beyond emergency response measures, and create a more sustainable and self-sufficient oxygen supply.

End

For further inquires

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ENDNOTES

[i] **Reach**, Syria situation overview in NWS
accessed on October 10, 2021 : https://reliefweb.int/sites/reliefweb.int/files/resources/REACH_SYR_Situation-Overview_Northwest-Syria_16-March-2020-1.pdf

[ii] **WHO**, Covid-19 Response and tracking dashboard in north west Syria
Accessed on October 10,2021:
https://app.powerbi.com/view?r=eyJrIjoiMmRiMGMxODMtNThkMi00NzA2LTk0MWUtYzc5YTgyNThlYWEyIiwidCI6ImY2MTBjMGI3LWJkMjQtNGIzOS04MTBiLTNkYzI4MGFmYjU5MCIsImMiOjh9&pageName=ReportSectionb57388c4c756b1036a93

[iii] **Health information unit**, HIS- COVID-19 Cumulative Report of September 2021
Accessed on October 10,2021:
https://hisunit.org/his-covid-19-cumulative-report/

[iv] **WHO**, Effectiveness of different forms of oxygen therapy for COVID-19 management
Accessed on May 20,2021:
https://apps.who.int/iris/bitstream/handle/10665/332305/WHO-AF-ARD-DAK-04-2020-eng.pdf?sequence=3&isAllowed=y