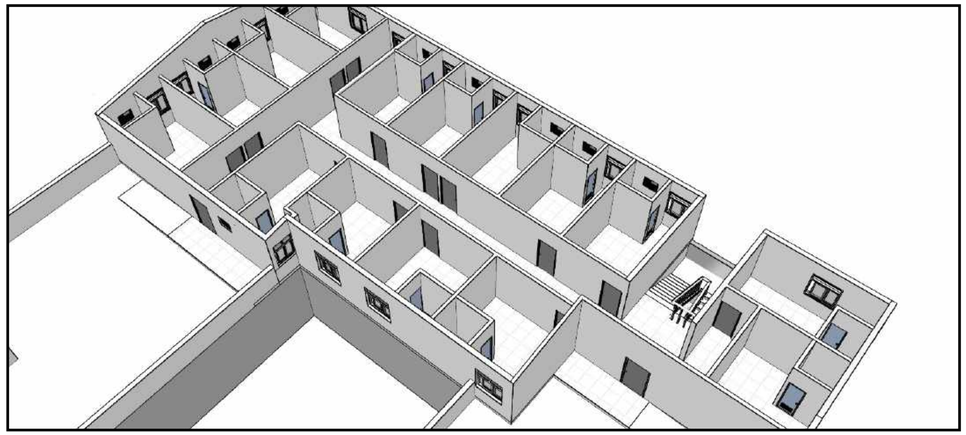

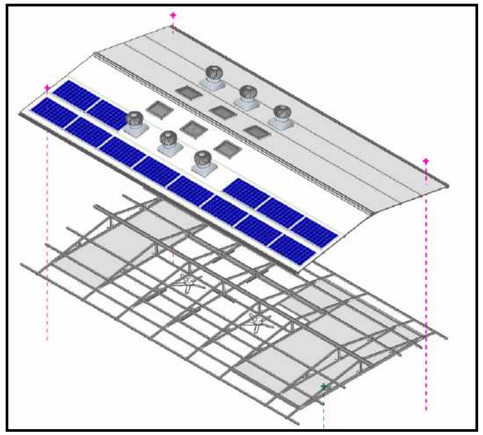

Sustainable Energy driven and Climate Responsive Infrastructure for ISOLATION & THERAPEUTIC units for COVID19

Version 2: April 18th, 2020

SELCO FOUNDATION

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Sustainable Energy driven and Climate Responsive Infrastructure for ISOLATION & THERAPEUTIC units for COVID19

Background and Introduction

SELCO over the last two decades has been striving to provide sustainable solutions, to under-served communities, that can enable better delivery of livelihoods, health and education. The primary philosophy being to eradicate poverty permanently an eco-system approach needs to be applied where the poor become asset owners and creators. The crisis SELCO was trying to mitigate was climate change and its effect on the poor communities.

The present crisis of COVID-19 is no different, but just that it has happened extremely suddenly and has impacted all parts of the society at once. Again, the biggest victims of this ongoing crisis will be the poor. SELCO's again believes the eco-system approach will help come up with appropriate solutions to the problems being created by COVID-19.

There are multiple interventions SELCO has furloughed and one of the most critical being in the health vertical. Working with experts from the medical field across the world, grassroots level health focussed NGOs and local governments SELCO has mapped out the initial set of interventions. The document presents some of the most critical ones that along with the stakeholders, the consortium would implement, and that then can replicated by others in different regions.

WHO has declared the COVID-19 (SARS-CoV-2) outbreak as Public Health Emergency of international concern and has raised the risk assessment of China, Regional Level and Global Level to Very High and "all countries should be prepared for containment, including active surveillance, early detection, isolation and case management, contact tracing and prevention of onward spread of SARS-CoV-2 infection.

- **Quarantine refers to separation of individuals who are not yet ill but have been exposed to COVID-19 and therefore have a potential to become ill. There will be voluntary home quarantine of contacts of suspect /confirmed cases. The guideline on home quarantine available on the website of the Ministry provides detail guidance on home quarantine.**
- **Isolation refers to separation of individuals who are ill and suspected or confirmed of COVID-19. All suspect cases detected in the containment/buffer zones (till a diagnosis is made), will be hospitalized and kept in isolation in a designated facility till such time they are tested negative. Persons testing positive for COVID-19 will remain to be hospitalized till such time 2 of their samples are tested negative as per Ministry of Health and Family Welfare (MoHFW) discharge policy. About 15% of the patients are likely to develop pneumonia, 5 % of whom requires ventilator management.**

COVID-19 crisis has provided an opportunity to prove that sustainable energy, appropriate building design, utilization of sustainable materials for construction and efficiency of medical equipments are all critical components for delivering emergency services. SELCO has worked with stakeholders to consider both the above criterion and have created a blueprint for the 1st set of interventions.

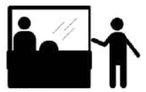
The added advantage being these components and interventions can be used even after the crisis is over, thus making it economically sustainable for governments to invest in them.

Sustainable Energy driven and Climate Responsive Infrastructure for ISOLATION & THERAPEUTIC units for COVID19

PATHWAYS TO RECOVERY

AWARENESS

IEC/ BCC



Community Kiosks

Training of healthcare staff, teachers

SCREENING

Patient History

IR Thermometer

Rapid diagnostic Tests

QUARANTINE

Home Based

Self Quarantine

Institution Based

Quarantine wards

IR Thermometer

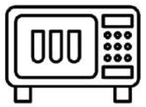
Water Heater / Pump / Storage

TESTING

Specimen storage

Specimen Transportation

Government approved kits and labs



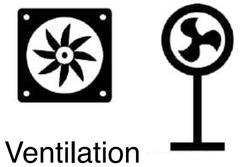
Autoclave

THERAPEUTIC CARE

ASYMPTOMATIC OR MILD

Isolation wards (Health Centres / Hospitals / Makeshift Units)

IR Thermometer



Ventilation

Water Heater / Pump / Storage

MODERATE

Dedicated wards

IR Thermometer

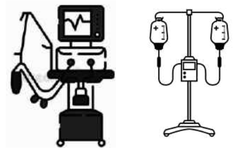
Oxygen Cylinder/ Concentrator

Pulse Oximeter

X-ray

SEVERE

ICU- District & Govt, Private hospitals



Ventilators
Infusion Pumps

Suction devices
Multi parameter monitor

Defibrillator
ECG

X-ray

Sustainable Energy driven and Climate Responsive Infrastructure for ISOLATION & THERAPEUTIC units for COVID19

Individual who are returnees from COVID19 affected areas, contacts with returnees or with confirmed cases etc. are the primary focus group for whom healthcare services are defined in this document. Depending on the stage of the COVID19 infection, medical services that need to be provided to the patient, the health staff and infrastructure (specifically technology) requirements differ.

It is also important to note that every positive COVID19 patient, infects 2-3 people on an average, Thus, contact tracing, identification, quarantine and screening of individuals who come in contact with a positive COVID19 patient is the first step to curbing the spread of the virus.

1. **Asymptomatic - Individuals with the potential of developing symptoms related to Covid19 or being carriers of the virus.**

   Quarantine facilities are spaces where individual can be separated from general public for 14 to 20 days for symptoms monitoring and test for Covid19 virus. Medical care is not required at these facilities and patients that develop symptoms, need to be isolated and transferred to medical care facilities.

   Depending on the geography and the context, temporary quarantine facilities might need to be set up to ensure that quarantine protocols are followed. For example, in urban slums or households/ neighbourhoods with high density, regions facing a sudden influx of migrants etc. These units can be set up as makeshift units by upgrading existing public infrastructure- following guidelines stated in the following page to ensure quality care and well-being.

2. **Asymptomatic / Mild - Tested Covid19 positive cases with no symptoms or mild symptoms, such as fever and Fatigue.**

   100% of Covid19 positive patients need physical and social **isolation with medical care and monitoring**. These units will be built as extensions to COVID FIRST LINE TREATMENT CENTRES (CFLTC). These can be housed out of primary care units- but the identification of the location needs to be in line with the guidelines on the following page.

3. **Moderate - Patients with fever and breathlessness and/or mild Pneumonia.**

   Close to 15% of Covid19 positive patients need **basic therapeutic care**. These units will be built as extensions to COVID FIRST LINE TREATMENT CENTRES (CFLTC). These can be housed out of primary care units- but the identification of the location needs to be in line with the guidelines on the following page. It is also important to note that the facility should be in close proximity to the designated COVID hospitals, and patients should be closely monitored, so they can be transferred for critical care if needed. Patients with pre-conditions (proving them to be high risk) should be prioritised in COVID Hospitals equipped for criticial care.

4. **Severe - Patients with fever, breathlessness and severe Pneumonia.**
   Close to 5% of Covid19 positive patients need **ICU care** who are critically ill. Among them 67% develop Acute respiratory Distress syndrome (ARDS).
   These units will be built as extensions to COVID HOSPITAL(CH). - (Source: WHO Clinical Management of COVID 19 Patents)

Sustainable Energy driven and Climate Responsive Infrastructure for ISOLATION & THERAPEUTIC units for COVID19

Requirement	Probable exposure	Covid Positive cases		
	Asymptomatic	Asymptomatic / Mild[1] - 100% approx	Moderate[2] - 15% approx	Severe[3] - 5% approx
	Quarantine ward	Isolation ward	Basic Therapeutic Care	ICU
Required Beds		300 beds per 100,000 population	4 beds per 100,000 population is essential	2 ICU beds per 100,000 population is essential
Human Resources (Med)	ANM, ASHA, AWW	Nurses, Medical Officers	General Medical Officer, Medicine Specialist, Paediatric, Microbiologist, Psychiatrists/ Psychologists, Nurses, Lab Technician, Public Health Specialist	Therapeutic Care HR + Respiratory specialist, anaesthesiologists, ICU nurses and technicians
Appliances	Exhaust fans, Pedestal fans, Lights, Mobile charger			
Medical Equipment	1 unit IR Thermometer**, Covid sample collection kits (ratio to affected population, 1hr = 10/15 tests)	1 unit IR Thermometer**	1 unit IR Thermometer**, 3 units Oxygen concentrator/ Cylinder, 6 units Pulse Oximeter (+2), 1 unit X-Ray Machine (for all wards)	4 units [Ventilators (with/ without splitters) - cylinders/ oxygen concentrator, infusion pump, suction devices, multipara monitor], 1 unit defibrillator (+1)
Spatial - Patient Beds per module	6ft by 8ft cubicle - 10 beds	6ft by 8ft cubicle - 10 beds	6ft by 8ft floor area - 6 Beds	10ft by 8ft floor area – 4* or 6 beds
Sanitation	4 toilets and 2 showers, 200 LPD Solar water heater Water Pump (as per need)	4 toilets and 2 showers, 200 LPD Solar water heater Water Pump (as per need)	2 toilets and 1 shower 100 LPD Solar water heater Water Pump (as per need)	
Vestibule	Common entry	Designated airlock entry and exit channels		

*Economical and Practical to set up 4 Bed vs. 2 Bed. Can be used as both therapeutic and ICU care by building 1 six bed unit per 6 Lakh population)

** IR Thermometer is suggested in places where more than 80 people are expected to be screened in a day. Further, in case IR thermometer is being used in a health facility, adequate training of staff on its use needs to be provided.

Infrastructure Gaps for Isolation and Therapeutic units for COVID19

Following gaps have been observed in the Infrastructure required for COVID19:

- Epidemic unpreparedness of district level health centers such as: unavailability of additional rooms, isolation beds, testing kits, quarantining & isolation facilities, ventilators and medical supplies; as the coping mechanism is very much co-related to quality infrastructure
- Local community centres and government buildings converted to temporary isolation wards lack access to reliable power supply- critical for well-being and treatment of the patients
- Due to unreliability of the grid (powercuts and voltage fluctuations), these buildings rely on generators resulting in high operational costs
- Not originally designed to serve as isolation wards, these temporary isolations wards also can lack basic sanitation such as clean water, disinfected toilets and drainage facilities
- Certain states/regions in India (which will also be the case across other developing countries) have severe shortages in ambulances and oxygen cylinders- leading to poor accessibility of health services and broken supply chains for critical infrastructure like ICUs
- Social distancing is a hard concept to follow in dense urban slums and vulnerable institutions catering to large number of individuals living in close proximity or using common infrastructure- such as toilets, water points etc. This may aggravate the community transfer of COVID-19

The shortfall of infrastructure, is being seen primarily in two ways

Option1 : Existing public buildings such as community centers, panchayat buildings, government residential schools, training centre of the NGOs, stadiums, etc can be upgraded and renovated to function as quarantine or isolation wards.

Option 2: Renovation, quick up-gradation and extension of existing hospitals

These two options have been detailed below and guidelines have been specified. However, as stated earlier, it is important to also note that the infrastructure required for COVID 19 (particularly for Isolation and Therapeutic Units) will need to be combination of built infrastructure and energy infrastructure- energy required to ensure smooth running of critical health equipments and to ensure the well-being of the patients and the staff.

Sustainable Energy driven and Climate Responsive Infrastructure for ISOLATION & THERAPEUTIC units for COVID19

Option 1: Renovation / Conversion of Existing Infrastructure

The first option for quick expansion of infrastructure gap has been to renovate and plan for conversion of existing infrastructure for quarantine and isolation wards. Across the world several public buildings (such as schools, community halls, marriage halls, panchayat / village administration offices etc), residential units such as hostels, hotels etc are being identified for this intervention. However, it is to be noted that this is not an option for therapeutic units for critical patients, since that requires a carefully designed health infrastructure ready to handle any level of complication, complemented by the right human resource, which is available only in a hospital.

Guidelines for renovation for renovation have been summarized alongside:

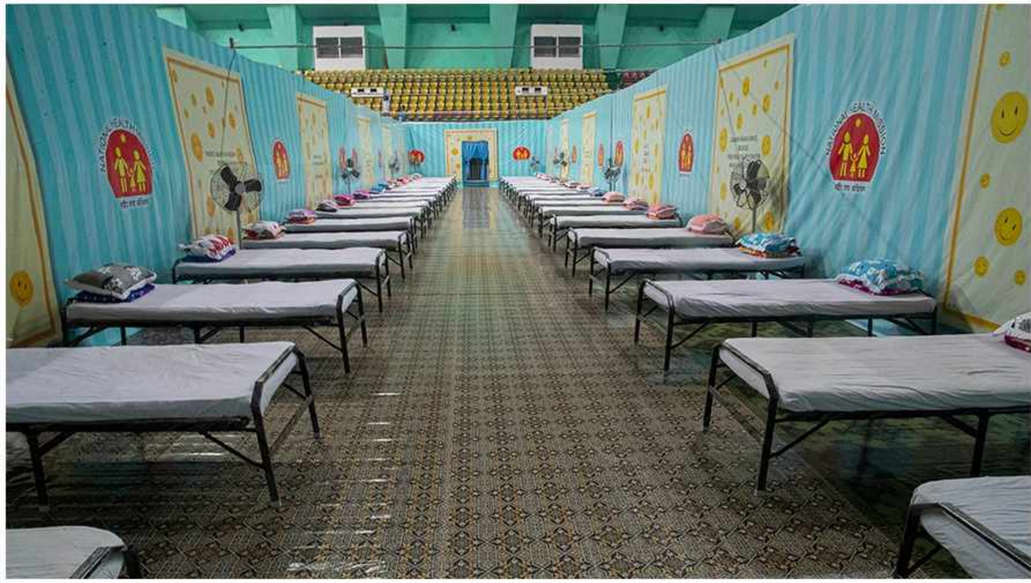
- **Demarcation of the entry/ exit points for asymptomatic and symptomatic patients, medical professional and caregivers need to be done**
- **Segregation of rooms as per containing of contaminants need to be ensuredIsolation protocol for symptomatic patients care like anteroom, airlock vestibule and segregated toilets need to be provided**
- **Ventilation need to be planned to prevent spread of infection in the form of windows, ventilators, exhaust fans and roof vents**
- **Locate the cubicles for easy access of toilets and bathrooms. Toilets and bathrooms need to be clean and functional.**
- **Demarcating of waste collection units and protocol to protect inhabitants and waste handlers**
- **Workstation to be provided for caregiver or medical professional for data logging and PC**
- **Kitchen or kitchen storage and distribution area to be available**
- **Services and Utilities like energy supply and reliance, water supply and proper sanitation need to be maintained**
- **Aerators to be placed on all taps to conserve water**

For more details, please refer to this link.

Note: The Renovation Guidelines currently do not account for energy demands of quarantine and isolation units. It is to be noted that specifically in rural scenarios or Tier II and Tier III Towns, it is important to identify energy assessment as a critical aspect. These units demand high energy for appliances and maintaining thermal comfort and lighting. ***Schools, Panchayat buildings, Community Halls etc suggested for makeshift Isolation and Quarantine Units usually have unreliable power, high degrees of voltage fluctuations and in some cases would require additional budgets for upgradation of transformer to account for heavy loads such as oxygen concentrators.***

Sustainable Energy driven and Climate Responsive Infrastructure for ISOLATION & THERAPEUTIC units for COVID19

Option 1: Renovation / Conversion of Existing Infrastructure



(From Left to Right) Hostels , Train Compartments and Marriage Halls converted into makeshift hospitals- Quarantine and Isolation Units

Sustainable Energy driven and Climate Responsive Infrastructure for ISOLATION & THERAPEUTIC units for COVID19

Option 2: Infrastructure Extension or Quick Capacity Up-gradation

Learning from some of the International response measures, guidelines for quick upgradations, extensions and creation of temporary infrastructure have been detailed in the following pages. These guidelines have been developed for design of the

1) built environment to ensure thermal efficiency, resilience and climate responsive-ness;
2) Identification of efficient technologies for the units
3) Energy system design

To develop these guidelines, existing solutions were also compared along various factors.

The factors considered for analysis are:

1) Health guidelines and spacial consideration for setting up isolation wards and cubicles
2) Customisation capacity of facility/ technology identified for upgradation to isolation wards
3) Infection Control and Ventilation
4) Thermal Comfort of patients and medical personnel
5) Utility and sanitation
6) Energy Performance
7) Construction and ease of setting up

(From Left to Right) Stadiums , Heavy Duty Canvas Tents and Shipping Containers being used to setup quick Quarantine and Isolation Units

Sustainable Energy driven and Climate Responsive Infrastructure for ISOLATION & THERAPEUTIC units for COVID19

Features	Retrofitted Shipping containers	PVC & Heavy Duty Canvas Tents	In-Situ Fabricated Units [2]	Pre-Assembled Units [3]
Health guidelines and spatial consideration for setting up isolation wards and cubicles	1-2 beds maximum can be accommodated per module	Large tents can contain as many as 50 to 100 beds if required		
Customisation capacity of facility/ technology identified for upgradation to isolation wards	Fixed unit dimension size limits customisation capacity for functions, windows and ventilation add-ons and other services.	Highly customisable to any layout and configuration at low costs.	Highly customisable and can adhere to any regulatory recommendations	Limited customisation availabe and can adhere to any regulatory recommendations
Infection Control and Ventilation	Lack of windows and methodologies to exhaust the space, limits capability to maintain hygienic conditions and infection control	Does not ensure complete air sealing or hygiene conditions - Increases the risk of spreading the infection and makes mechanical ventilation more inefficient	Can be attained by introducing all passive and active measures for comfort	Can be attained by introducing all passive and active measures for comfort
Thermal Comfort of patients and medical personnel	Metal envelope has low thermal efficiency resulting in strong dependence on air conditioner systems or add-on insulation	No passive insulation (especially for heat stress regions) and no weather protectant from rains, climate stresses or disasters	More insulated wall and roof panels need to be provided to achieve higher levels of comfort	More insulated wall and roof panels need to be provided to achieve higher levels of comfort
Utility and sanitation	Addition of plumbing and sanitation facilities require high amount of customisation	Porta-toilets or cabins to be provided as add-ons to ensure airlock spaces for infection control	Can be built completely airlock and with hygienic conditions	Can be built completely airlock and with hygienic conditions
Energy Performance	Lack of windows reduces natural lighting and increases dependency on artificial lighting even during daytime High costs of air conditioning for comfort	Dependency on artificial lighting even during daytime unless translucent tent envelop or window flaps are provided High expense on air conditioning for thermal comfort	Efficiency can be improved as long as passive methods and climate responsive design is adopted	Efficiency can be improved as long as passive methods and climate responsive design is adopted
Construction and ease of setting up	If standard designs are prepared, customisation can happen in manufacturing facilities in bulk and prefabricated High cost to engage skilled professionals in fabricated construction/retrofit. Long prefabrication process. Logistics and transportation is difficult due to unit being a monolit structure - Hard to reach regions with poor road infrastructure unless air lifted - standard sizes of trucking vehicles to be used	**Not recommended during or in regions with heavy winds** **Fast construction can be achieved**	While most components can be pre-fabricated, high dependency of energy and skilled labour force on site to execute. Quick construction and prefabrication time.	Long process for prefabrication and similar challenges is transport of shipping containers

Table 1: Comparison of Existing Solutions for Infrastructure Up-gradation and Extension

[2] MS framework; Option 1- Walling: Bison panels; Roofing: Colour coated sheet, Option 2: Walling: PUF panels, Roofing: PUF panel
[3] Monolit module with MS/ LGS Frame; Materials: Gypsum, EPS, Puf Sandwich

Recommended Technology Typology

Based on the comparison the previous page, the 2 Prefabricated technologies were deemed more viable due to their customizability, thermal performance, energy efficiency and ease and timeline for construction. The timelines and skill force for the two recommended technologies have been further detailed below.

		Technology 1			Technology 2		
Technology Description		Prefabricated and pre finished wall panels with low U-values and cross sectional light gauge steel frames, Wall panels need to have high customisable capacity for addition of windows, ventilators and built in furniture support strength			Prefabricated modules with telescopic wall panels that reduces large volumes into smaller units incrementally. Telescopic walls have air gap insulation to improve indoor comfort		
Skill force		Fabrication and carpentry team for installation with DG Set, civil masons for foundation and plinth work, Electrician and plumbers. 50% of fabrication in manufacturing units and 50% on site installation			Minimum on site fabrication for installation with DG Set, civil masons for foundation and plinth work, Electrician and plumbers and unskilled labour for installation Most of the fabrication happens in manufacturing units and on-site timelines are short for installation		
Timeline		**1 Unit (10 Beds)**	**5 Units (50 Beds)**	**10 Units (100 Beds)**	**1 Unit (10 Beds)**	**5 Units (50 Beds)**	**10 Units (100 Beds)**
	Steel Fabrication	3 Days	7 Days	9 Days	20 Days	30 Days	30 Days
	Delivery on site	3 Days	3 Days	3 Days	3 Days	3 Days	3 Days
	On site Installation	3 Days	8 Days	13 Days	1 Day	3 Days	10 Days
	Total	**9 Days**	**18 Days**	**25 Days**	**24 Days**	**36 Days**	**43 Days**
	Note	**From manufacturing to assembly on site, the technology requires minimal time. The flat pack transportation option is apt for construction even in remote inaccessible areas**			**Minimal time on the field due to ease of assembly and low skilled labour requirement. However, transportation (loading and unloading) requires precision ensuring no damage to the fabricated unit.**		

Sustainable Energy driven and Climate Responsive Infrastructure for ISOLATION & THERAPEUTIC units for COVID19

Setting up Sustainable Energy driven and Climate Responsive Infrastructure

The infrastructure can be categorised into 4 broad spatial classification

1. Entry and Exit Zones

Separate entry and exits need to be designed for:

a. Asymptomatic Individual
b. Medical Professional and Caregivers
c. Waste Handlers and other service providers

2. Sanitation, Water Supply and Waste Management

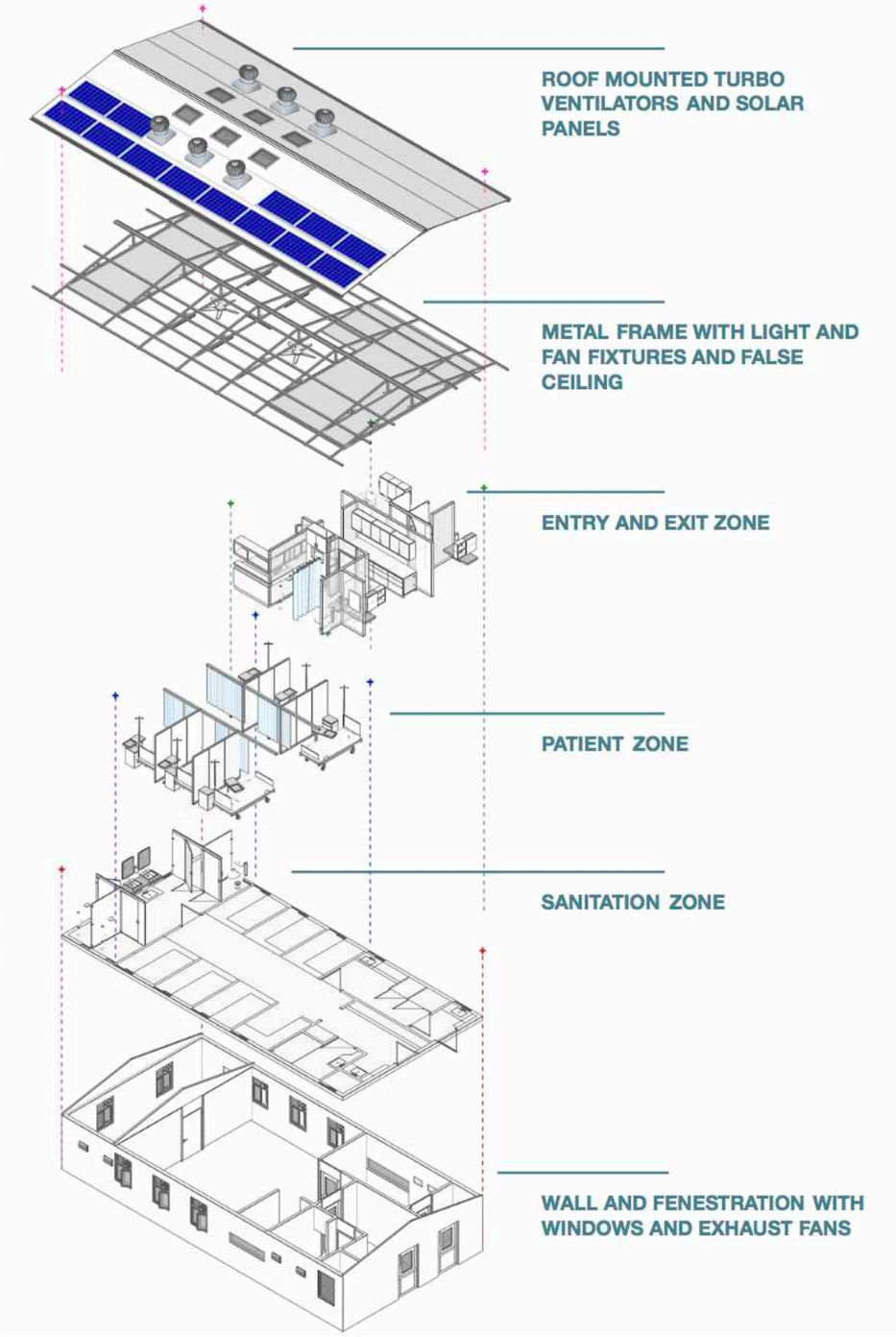
It is important to plan for separate sanitation facilities for medical professionals and patients at different infection stages. Additionally, in the wards following guideline should be followed for the patients:

a. 1 shower per 4 beds
b. 1 toilet per 2 beds

3. Patient Accommodation (Infection Control and Ventilation)

Depending on the severity of the conditions, the patient accommodation needs to be designed to ensure infection control and protocols for ventilation

a. Asymptomatic - Not Positive
b. Asymptomatic - Positive and Mild Symptomatic
c. Moderate Symptomatic
d. Severe Symptomatic



Sustainable Energy driven and Climate Responsive Infrastructure for ISOLATION & THERAPEUTIC units for COVID19

1. Entry and Exit Zone - Vestibule Design for Symptomatic patients

1. A controlled area to transfer supplies, equipment and persons (Asymptomatic Individual, Medical Professional and Caregivers, Waste Handlers and other service providers) without contamination spread

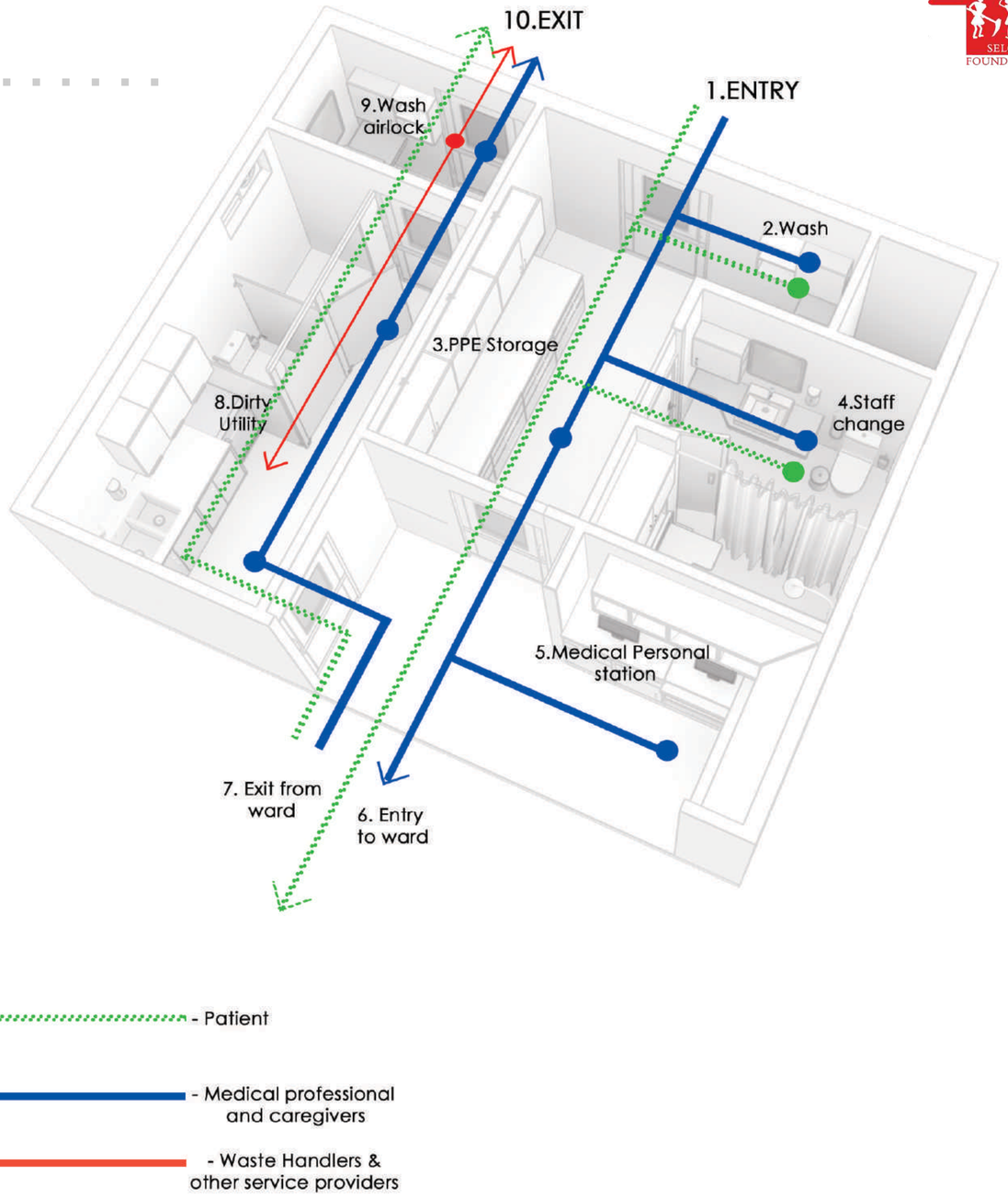
2. A barrier to prevent loss of pressurisation. Controls the entry or exit of contaminated air when the anteroom door is opened

3. Personal protective equipment (PPE) or clothing can be donned or removed prior to entry/exit of the isolated ward

4. Storage of Personal Protective Equipment (PPE) i.e. gowns and gloves

5. Anterooms should not be shared between Isolation rooms.

6. Waste disposed - PPE suits, masks, utensils, clothes etc needs to be collected and stored in the dirty utility and evacuated by bio medical waste handlers only.



2. Patient Accommodation

Infection Control and Ventilation

The principles to achieve thermal comfort and ventilate a ward with patients with or without symptoms of Covid-19 are the same — building design, type of building, building function, building form, envelope, natural ventilation strategy, internal distribution of spaces and functions, thermal mass, heating, ventilation and air-conditioning

Process related to **natural ventilation** design:

Site design

1. Building location, layout, building orientation, landscaping
- Overhangs and projections may be used. Self-shading by the building itself and remote shading (e.g. by another building or trees)
- Naturally ventilated buildings need not be narrow. The natural air currents may penetrate deeply into a building. Large halls can be built

2. Vent opening design — position of openings, types of openings, sizing of openings, control strategy
- Ventilation openings should not be blocked, and furniture layout and internal partitioning must not restrict the intended flow path and opening access. Mosquito mesh on all windows and ventilators. Isolation facility should have large windows on opposite walls of the room allowing a natural unidirectional flow and air changes.
- Daylight and glare control — windows may be provided with a screen to avoid the direct sunlight. The shape and the position of the window openings are also important. The colour and the finishes of the surfaces must also be chosen properly for a comfortable level of lighting and glare control

3. Active measure for cooling and ventilation
- During hot and humid weather, local spot cooling or personalized cooling systems may be used (e.g. by using ceiling fans or desk fans)

Process related to mechanical ventilation design:

- Negative pressure needs to be created to prevent transfer of contaminants between rooms. This is achieved with exhausting a room with higher frequency
- Ensure adequate room ventilation, ensuring 12 air changes/ hour and filtering of exhaust air.
- Wind chill effect from table top fans with very low air flow rate to be provided for additional heat stress relief. Ceiling fans at low rpm can be provided if needed else to be completely avoided while setting up units to prevent contamination spread.

(Optional) Air Conditioning

- The patient exhaust air duct should be independent of the general area exhaust air system to reduce risk of contamination due to back draughts and should discharge away from staff, visitor and entrance vestibule.
- Negative pressure vestibule to be create to prevent contaminated air to backflow
- Air filtration via HEPA filters to be provided
- High rates of air exchange and no recycling air - ideally VAV system ACs to be provided

3. Sanitation, Water Supply and Waster Management

Through ventilation best practices we can maintain and contain the spread of infection. Other means of cross contamination are from common services. It is vital to separate service routes between the covid19 positive individuals and service providers for:

- waste handling - dry and wet waste from food,
- clothing and bed linens,
- bio medical waste as well as
- waste water and fecal waste,
- water supply - drinking and utility
- electrical

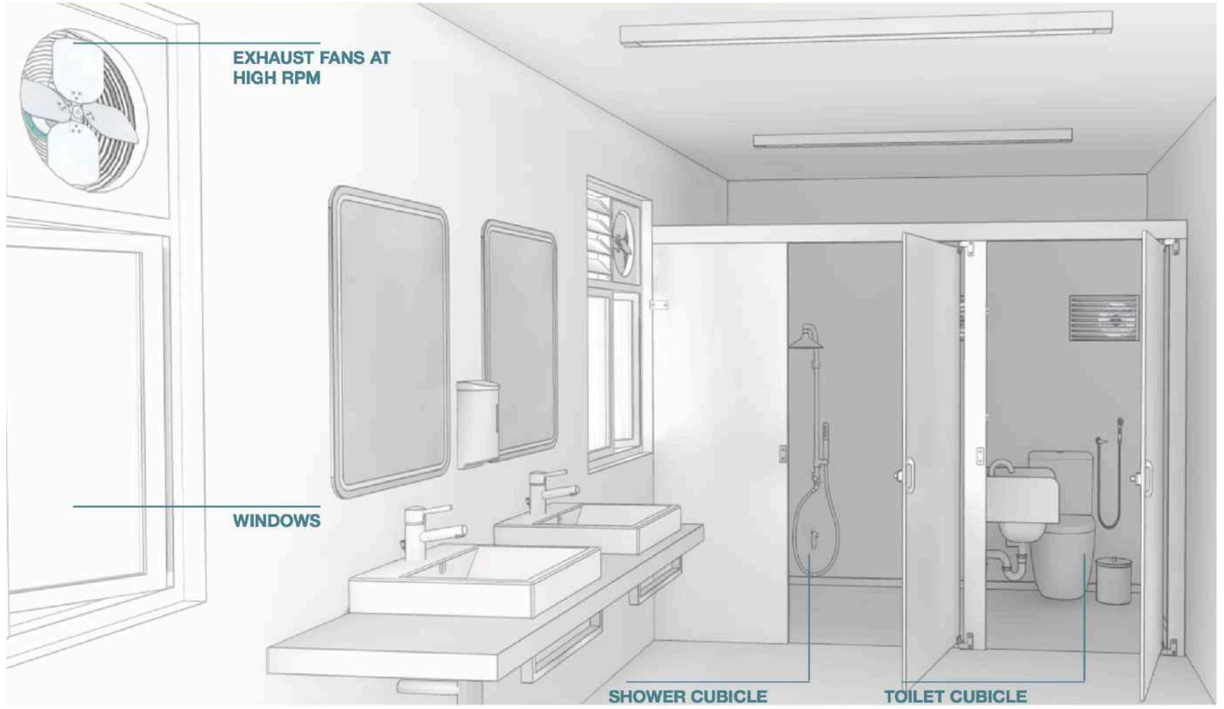
General Precautions
Workers should wear appropriate personal protective equipment (PPE) while managing waste even when managing bed linen, dirty utensils and other personal belonging of patients.

All health care waste produced during the care of COVID 19 patients should be collected safely in designated containers and bags, treated, and then safely disposed of or treated, or both, preferably onsite. If waste is moved off-site, it is critical to understand where and how it will be treated and destroyed. All who handle health care waste should wear appropriate PPE and perform hand hygiene after removing it.

Each toilet needs to be provided with high RPM exhaust fan to prevent contamination spread post usage by patients and while cleaning of toilets and bathing areas twice a day. Isolated septic tanks to be provided for toilets used by patients and contained till properly disposed, treated or sealed.

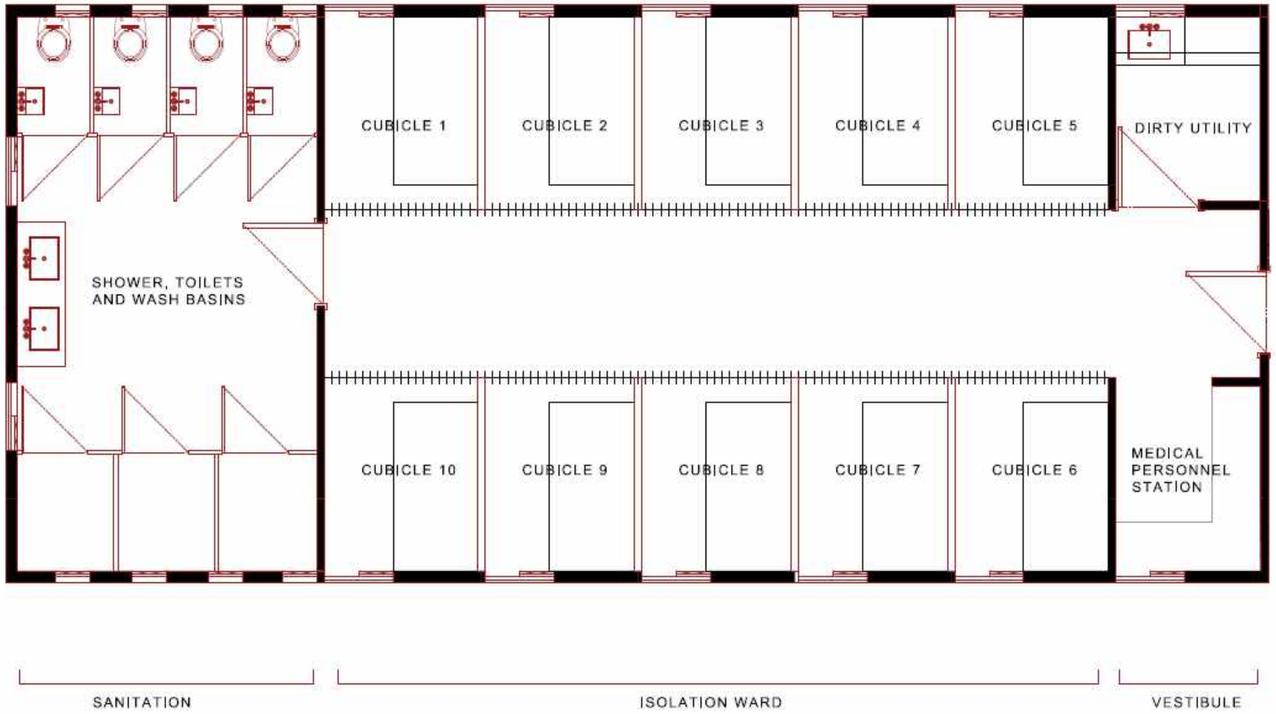
Sealed bathroom drains, and backflow valves on sprayers and faucets to prevent aerosolized faecal matter from entering the plumbing or ventilation system is vital.

For more information, refer to: WHO guidance on water sanitation and healthcare waste management in relation to covid-19



Sustainable Energy driven and Climate Responsive Infrastructure for ISOLATION & THERAPEUTIC units for COVID19

A. Quarantine (Asymptomatic Patients) ward



Quarantine rooms are designated for asymptomatic individuals.

Quarantine separates and restricts the movement of people who were exposed to a contagious disease to gauge their symptoms.

Individual modules of 10 beds can be added to existing hospitals or public infrastructure.

Segregated area for medical personnel and dirty utilities to be provided. Clothes, plates and other personal belongings of quarantined individuals to be stored and isolated for disposal and cleaning.

Sustainable Energy driven and Climate Responsive Infrastructure for ISOLATION & THERAPEUTIC units for COVID19

A. Quarantine (Asymptomatic Patients) ward :10 Beds Module - Load Details (AC/ DC Power Supply 220-240 Vac)

S. No.	Room Type	Room Name	Load Details	Specifications	Load Wattage	Quantity	Usage Hours
1	Vestibule	Medical Personal Station	Exhaust Fan	min 130 CFM (Cubic Feet per Minute to allow 12 air changes per hour)	40-60	1	12
			LED Tube Light	48 sq. ft hospital floor area requires min 2141 Lumens with medium illumination intensity / 16 watts	20	1	10
			Mobile Charger	USB Type	10	3	4
			WiFi Modem		10	3	24
2		Dirty Utility	Exhaust Fan	min 130 CFM (Cubic Feet per Minute to allow 12 air changes per hour)	40-60	1	12
			LED Tubelight	48 sq. ft hospital floor area requires min 2141 Lumens with medium illumination intensity / 16 watts	20	1	10
3	Isolation Ward	10 Cubicles	LED Tubelight	48 sq. ft hospital floor area requires min 2141 Lumens with medium illumination intensity / 16 watts	20	10	7
			Mobile Charging	USB Type	10	10	3
			Exhaust Fan	min 130 CFM (Cubic Feet per Minute to allow 12 air changes per hour)	40	10	12
			Infrared Thermometer	Handheld		1	Battery operated
4	Sanitation Area	Toilets/ Shower	LED Bulbs	12 sq. ft hospital floor area requires min 335 Lumens with medium illumination intensity / 2 watts	6	4	4
			LED Bulbs	16 sq. ft hospital floor area requires min 714 Lumens with medium illumination intensity / 5 watts	6	3	4
			Exhaust Fan	min 50 CFM (Cubic Feet per Minute to allow 12 air changes per hour)	20-30	4	4
5		Wash Basin	LED Tubelight		20	2	5

Sustainable Energy driven and Climate Responsive Infrastructure for ISOLATION & THERAPEUTIC units for COVID19

Solar System Design:

1. **Solar powering Quarantine ward without considering table fan**

Max Load that can be connected	1022 W
Max units of energy (kWh) usage per day	8.7 units
System Voltage	96 V

Assumptions *Sunshine hours: 5 hours* *Depth of Discharge (DoD): 80%* *Days of Autonomy: 1 days*		**Assumptions** *Sunshine hours: 5 hours* *Depth of Discharge (DoD): 80%* *Days of Autonomy: 2 days*	
Solar Panel	**4.5 kWp**	**Solar Panel**	**4.5 kWp**
Solar Battery	**150 Ah, 96 Vdc**	**Solar Battery**	**300 Ah, 96 Vdc**
Estimated Solar Cost: Rs. 4,20,000/-*		**Estimated Solar Cost: Rs. 5,35,000/-***	

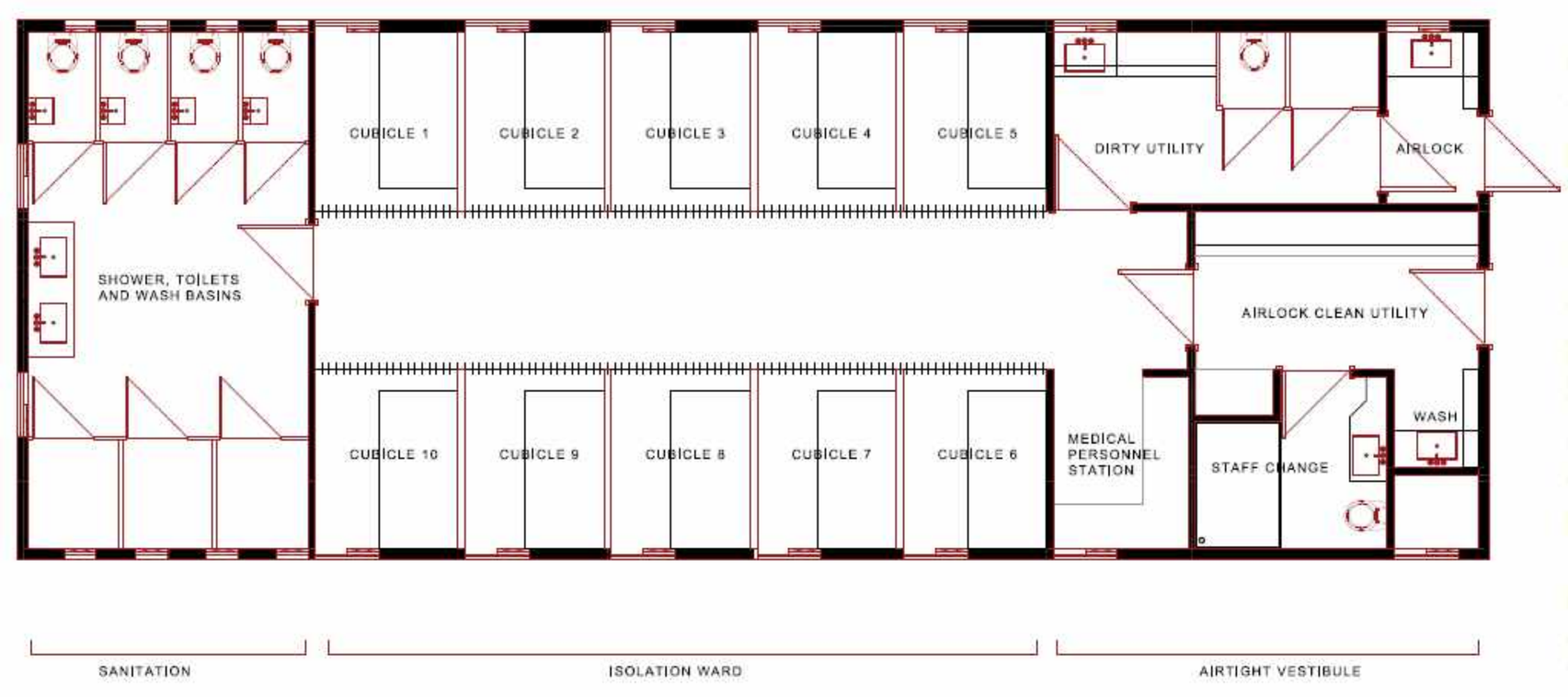
Sustainable Energy driven and Climate Responsive Infrastructure for ISOLATION & THERAPEUTIC units for COVID19

Solar powering Quarantine ward
with considering a table fan at
1) Medical Personal Station (1 no.)
2) Isolation Ward (10 nos for 10 cubicles)

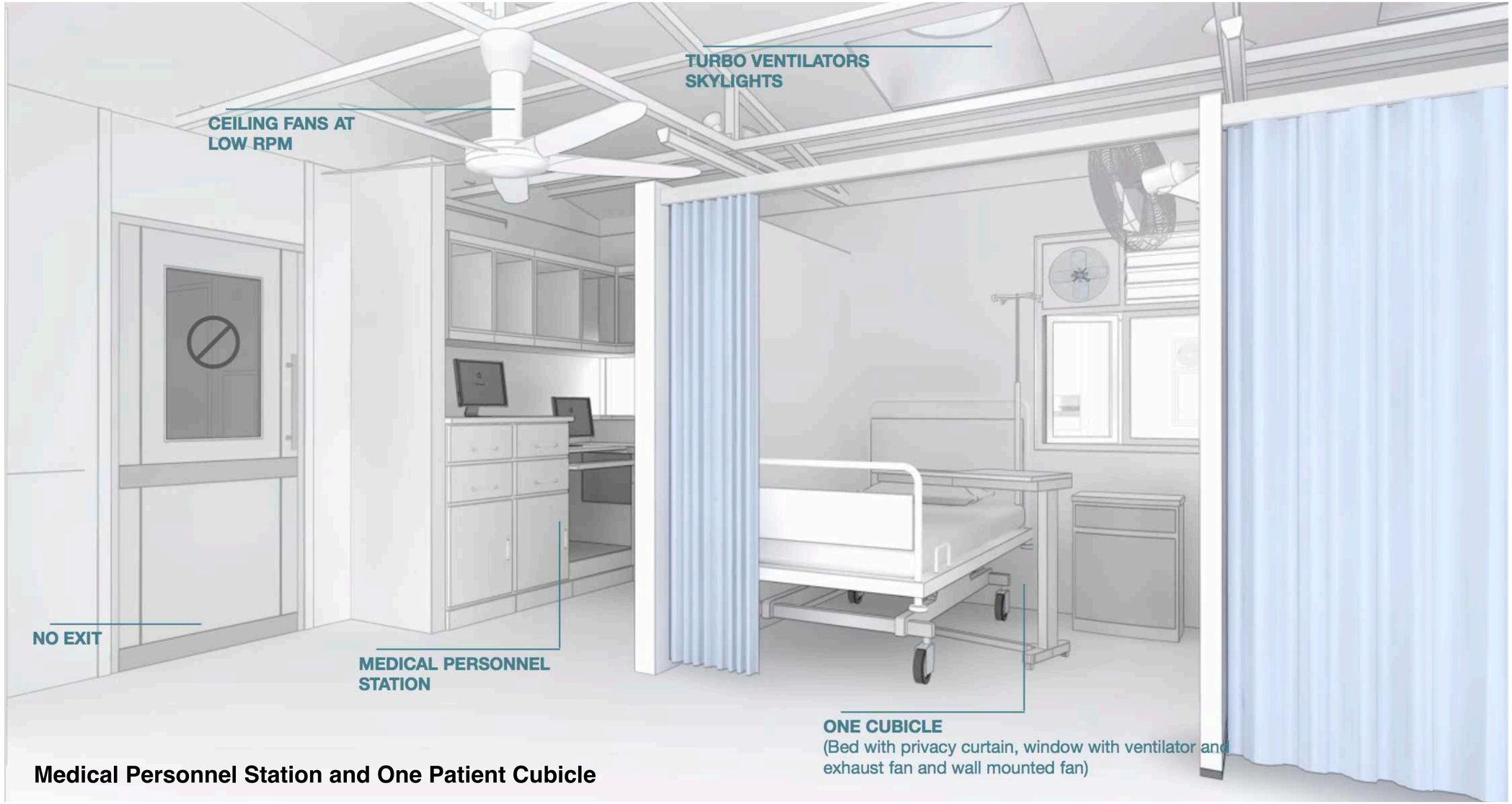
Max Load that can be connected	1132 W
Max units of energy (kWh) usage per day	10.088 units
System Voltage	96 V

Assumptions *Sunshine hours: 5 hours* *Load Efficiency: 80%* *Days of Autonomy: 1 days*		**Assumptions** *Sunshine hours: 5 hours* *Load Efficiency: 80%* *Days of Autonomy: 2 days*	
Solar Panel	**5 kWp**	**Solar Panel**	**5 kWp**
Solar Battery	**180 Ah, 96 Vdc**	**Solar Battery**	**360 Ah, 96 Vdc**
Estimated Solar Cost: Rs. 4,75,000/-		**Estimated Solar Cost: Rs. 5,95,000/-**	

B. Isolation (Symptomatic Patients - Mild) ward

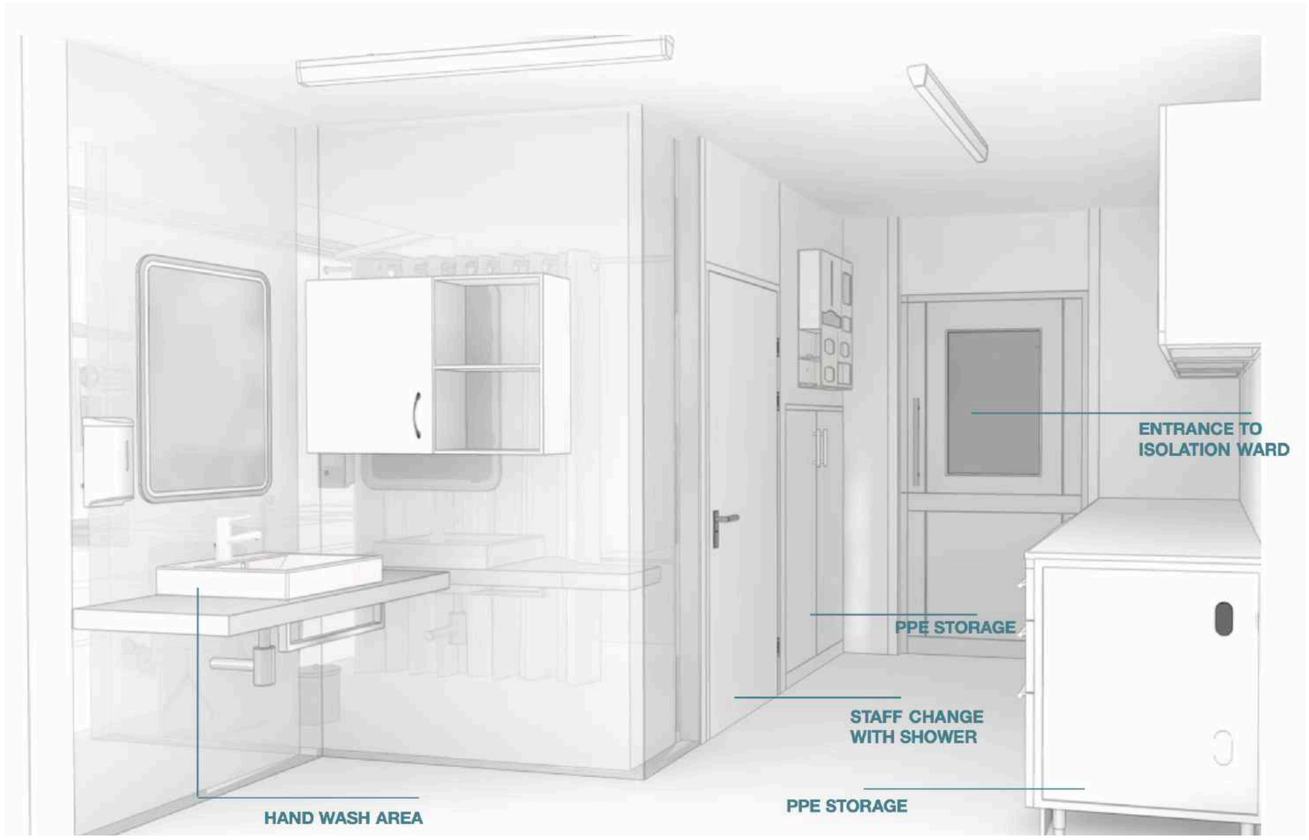


B. Isolation (Symptomatic Patients - Mild) ward

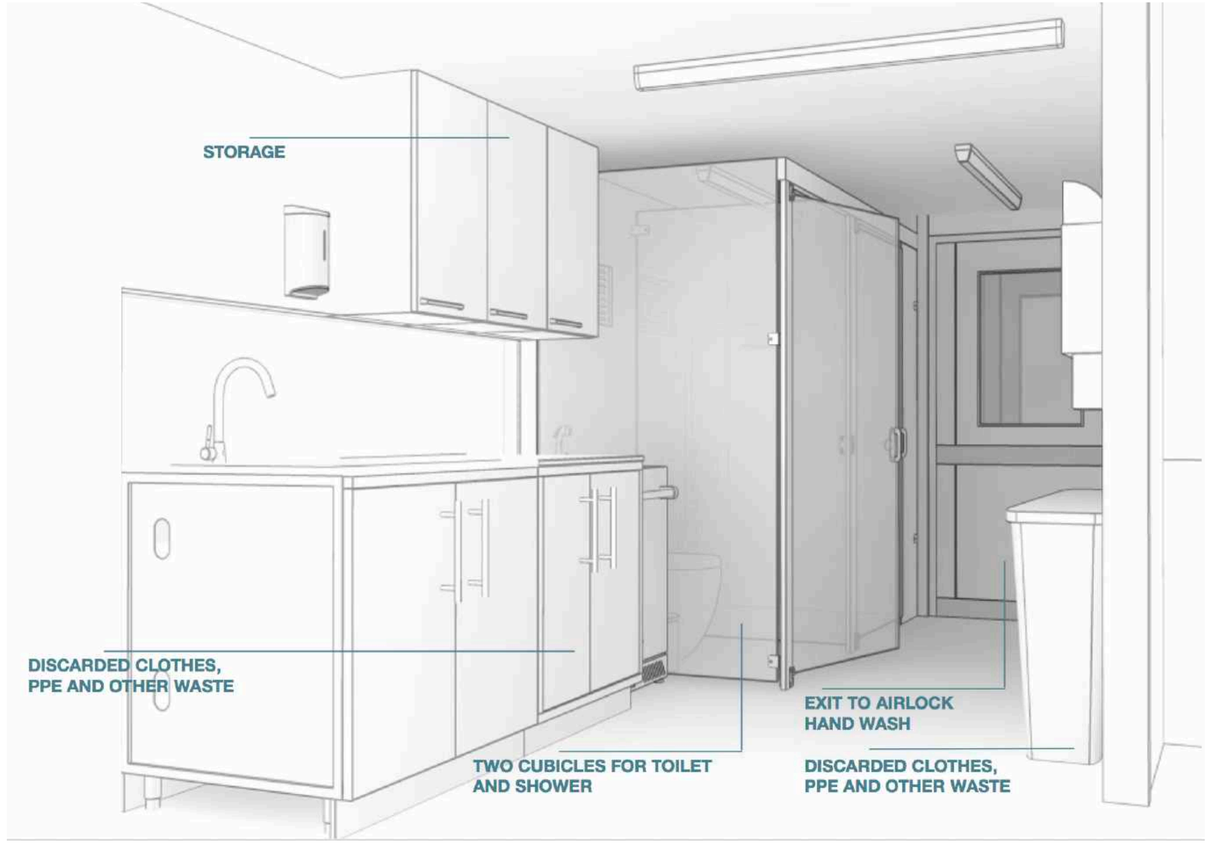


Medical Personnel Station and One Patient Cubicle

B. Isolation (Symptomatic Patients - Mild) ward



Entrance- Airlock Clean Utility



Exit- Dirty Utility

Sustainable Energy driven and Climate Responsive Infrastructure for ISOLATION & THERAPEUTIC units for COVID19

B. Isolation (Symptomatic Patients) ward : 10 Beds Module - Load Details (AC/ DC Power Supply 220-240 Vac)

S. No.	Room Type	Room Name	Load Details	Specifications	Load Wattage	Quantity	Usage Hours
1	Airtight Vestibule	Medical Personal Station	Exhaust Fan	min 130 CFM (Cubic Feet per Minute to allow 12 air changes per hour)	40-60	1	12
			LED Tubelight	48 sq. ft hospital floor area requires min 2141 Lumens with medium illumination intensity / 16 watts	20	1	10
			Mobile Charger	USB Type	10	3	4
			WiFi Modem		10	3	24
2		Staff Change	LED Bulb	80 sq. ft bathroom area requires min 2230 Lumens with high illumination intensity/ 20 watts	10	2 (divided amoung the shower and toilet area)	3
3		Wash	LED Bulb		6	2	4
		Dirty Utility	Exhaust Fan	min 130 CFM (Cubic Feet per Minute to allow 12 air changes per hour)	40-60	1	12
4			LED Tubelight		20	1	3
			LED Bulb		6	2	3
5	Isolation Ward	10 Cubicles	LED Tubelight	48 sq. ft hospital floor area requires min 2141 Lumens with medium illumination intensity / 16 watts	20	10	7
			Mobile Charging	USB Type	10	10	3
			Exhaust Fan	min 130 CFM (Cubic Feet per Minute to allow 12 air changes per hour)	40	10	12
			Infrared Thermometer	Handheld		1	Battery
6	Sanitation Area	Toilets/ Shower	LED Bulbs	12 sq. ft hospital floor area requires min 335 Lumens with medium illumination intensity / 2 watts	6	4	4
			LED Bulbs	16 sq. ft hospital floor area requires min 714 Lumens with medium illumination intensity / 5 watts	6	3	4
			Exhaust Fan	min 50 CFM (Cubic Feet per Minute to allow 12 air changes per hour)	20-30	4	4
7		Wash Basin	LED Tubelight		20	2	5

Solar System Design

1. Solar powering Quarantine ward without considering Pedestal fan

Max Load that can be connected	1066 W
Max units of energy (kWh) usage per day	8.9 units
System Voltage	96 V

Assumptions *Sunshine hours: 5 hours* *Depth of Discharge (DoD): 80%* *Days of Autonomy: 1 days*		**Assumptions** *Sunshine hours: 5 hours* *Depth of Discharge (DoD): 80%* *Days of Autonomy: 2 days*	
Solar Panel	**4.5 kWp**	**Solar Panel**	**4.5 kWp**
Solar Battery	**150 Ah, 96 Vdc**	**Solar Battery**	**300 Ah, 96 Vdc**
Estimated Solar Cost: Rs. 4,20,000/-		**Estimated Solar Cost: Rs. 5,35,000/-**	

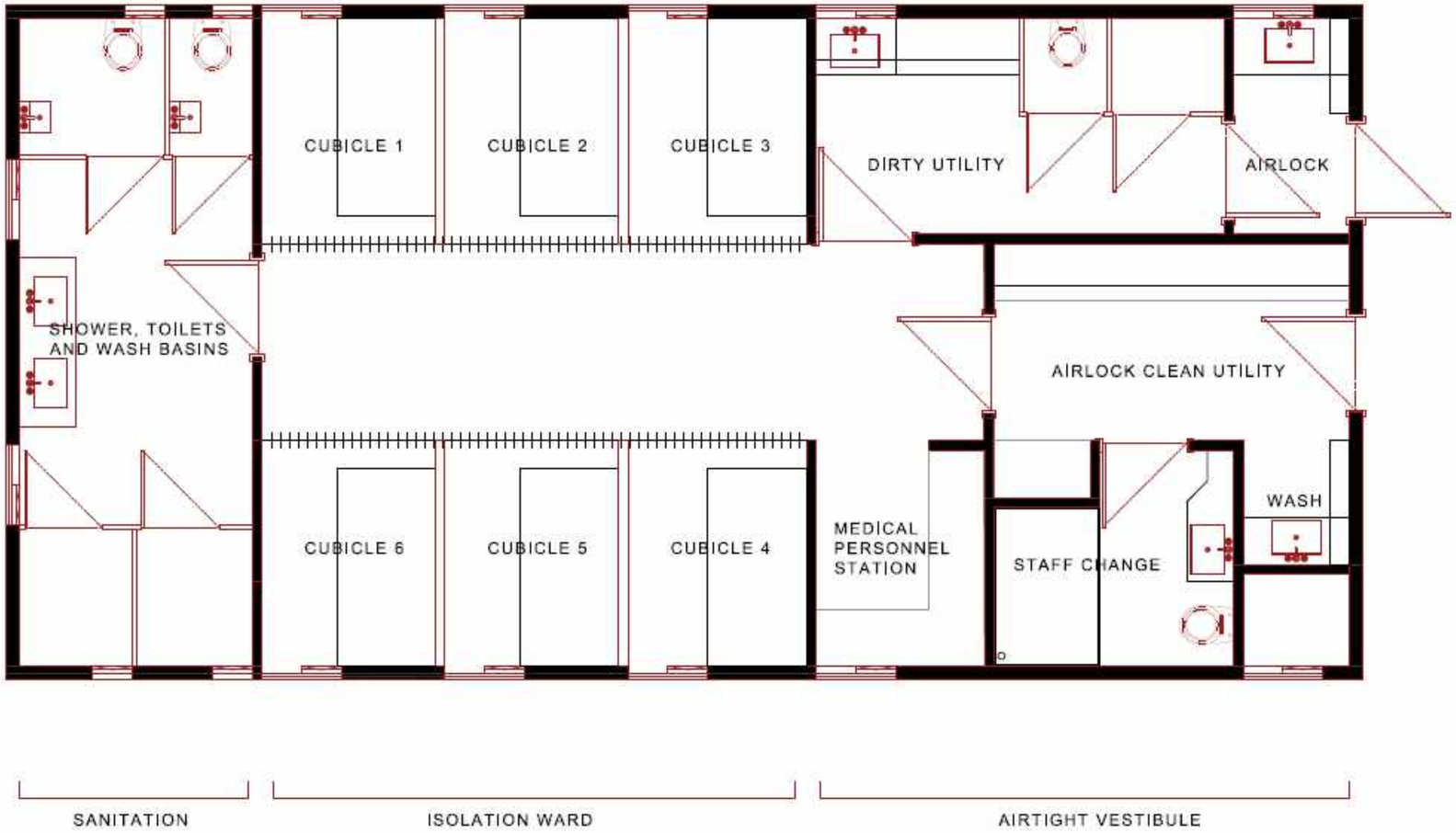
Sustainable Energy driven and Climate Responsive Infrastructure for ISOLATION & THERAPEUTIC units for COVID19

Solar powering Quarantine ward
with considering a table fan at
1) Medical Personal Station (1 no.)
2) Isolation Ward (10 nos for 10 cubicles)

Max Load that can be connected	1132 W
Max units of energy (kWh) usage per day	10.088 units
System Voltage	96 V

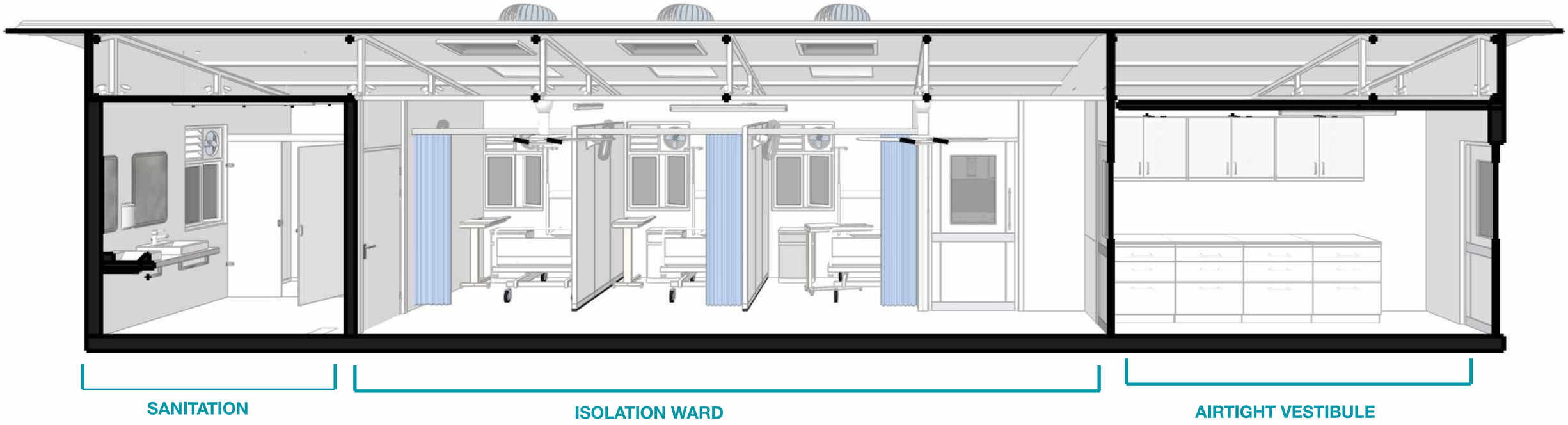
Assumptions *Sunshine hours: 5 hours* *Load Efficiency: 80%* *Days of Autonomy: 1 days*		**Assumptions** *Sunshine hours: 5 hours* *Load Efficiency: 80%* *Days of Autonomy: 2 days*	
Solar Panel	**5 kWp**	**Solar Panel**	**5 kWp**
Solar Battery	**180 Ah, 96 Vdc**	**Solar Battery**	**360 Ah, 96 Vdc**
Estimated Solar Cost: Rs. 4,75,000/-		**Estimated Solar Cost: Rs. 5,95,000/-**	

C. Therapeutic Care (Moderate Symptoms) ward



Patients with moderate to severe symptoms are required to be isolated with additional care in the form of Oxygen concentrator or Cylinder and Pulse Oximeter.

C. Therapeutic Care (Moderate Symptoms) ward



C. Therapeutic Care (Moderate Symptoms) ward

Sustainable Energy driven and Climate Responsive Infrastructure for ISOLATION & THERAPEUTIC units for COVID19

C. Basic Therapeutic Care - Load Details (AC/ DC Power Supply 220-240 Vac)

S. No.	Room Type	Room Name	Load Details	Specifications	Load Wattage	Quantity	Usage Hours
1	Airtight Vestibule	Medical Personal Station	Exhaust Fan	min 130 CFM (Cubic Feet per Minute to allow 12 air changes per hour)	40-60	1	12
			LED Tubelight	48 sq. ft hospital floor area requires min 2141 Lumens with medium illumination intensity / 16 watts	20	1	10
			Mobile Charger	USB Type	10	3	4
			WiFi Modem		10	3	24
2		Staff Change	LED Bulb	80 sq. ft bathroom area requires min 2230 Lumens with high illumination intensity/ 20 watts	10	2 (divided amoung the shower and toilet area)	3
3		Wash	LED Bulb		6	2	4
4		Dirty Utility	Exhaust Fan	min 130 CFM (Cubic Feet per Minute to allow 12 air changes per hour)	40-60	1	12
			LED Tubelight		20	1	3
			LED Bulb		6	2	3
5	Isolation Ward	6 Cubicles	LED Tubelight	48 sq. ft hospital floor area requires min 2141 Lumens with medium illumination intensity / 16 watts	20	6	7
			Mobile Charging	USB Type	10	6	3
			Exhaust Fan	min 130 CFM (Cubic Feet per Minute to allow 12 air changes per hour)	40	6	12
			Infrared Thermometer	Handheld		1	Battery operated
			Oxygen Concnentrator	87% to 96% at 0.5 to 5 L/min (portable)	300-400	3 (50 % of moderately affected cases requires oxygen concentrator)	14
			Pulse Oxymeter	Portable		6	
6	Sanitation Area	Toilets/ Shower	LED Bulbs	12 sq. ft hospital floor area requires min 335 Lumens with medium illumination intensity / 2 watts	6	4	4
			Exhaust Fan	min 50 CFM (Cubic Feet per Minute to allow 12 air changes per hour)	20-30	4	4
7		Wash Basin	LED Tubelight		20	1	5

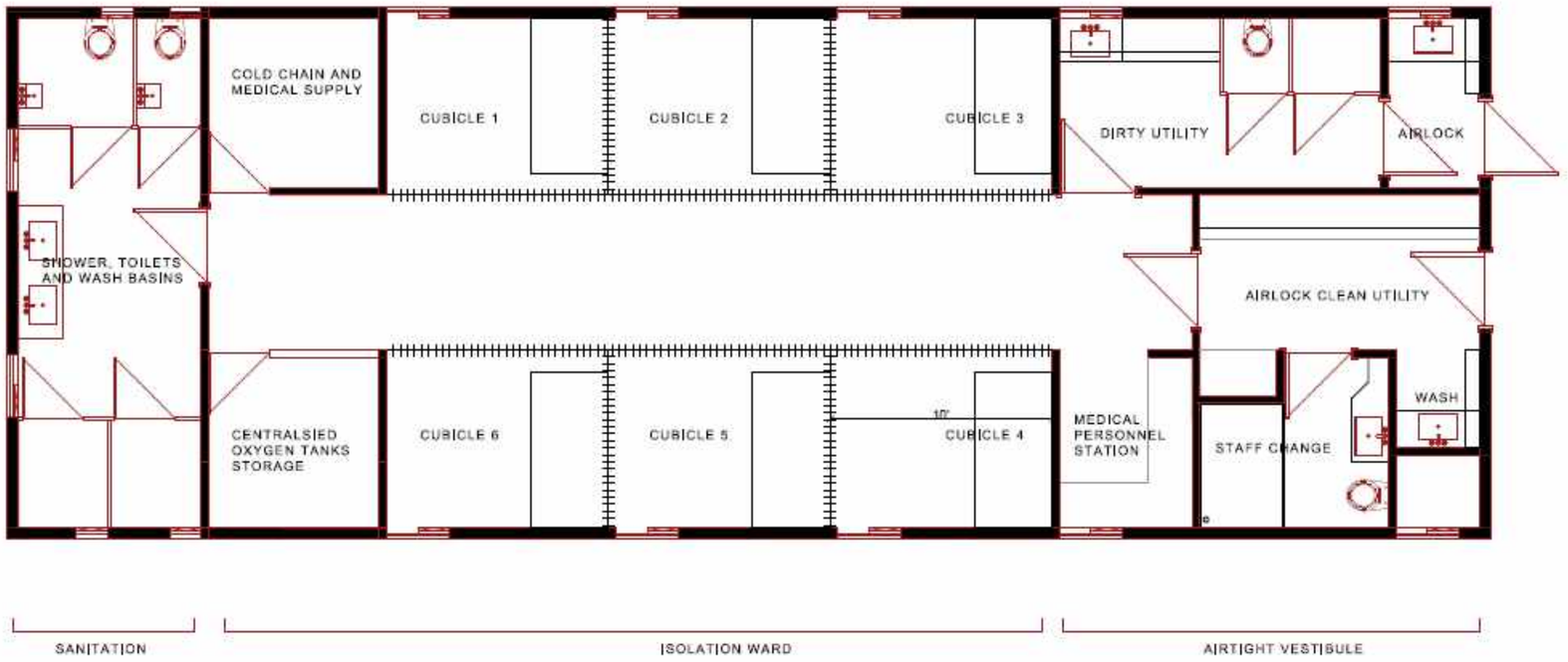
Solar System Design:

1. **Solar powering Quarantine ward without considering table fan**

Max Load that can be connected	1798 W
Max units of energy (kWh) usage per day	20.8 units
System Voltage	240 V

Assumptions *Sunshine hours: 5 hours* *Depth of Discharge (DoD): 80%* *Days of Autonomy: 1 days*		**Assumptions** *Sunshine hours: 5 hours* *Depth of Discharge (DoD): 80%* *Days of Autonomy: 2 days*	
Solar Panel	11 kWp	Solar Panel	11 kWp
Solar Battery	150 Ah, 240 Vdc	Solar Battery	300 Ah, 240 Vdc
Estimated Solar Cost: Rs. 12,00,000/- (Approx.)		Estimated Solar Cost: Rs. 15,00,000/- (Approx.)	

D. ICU (Severe Symptoms) ward - 6 Beds

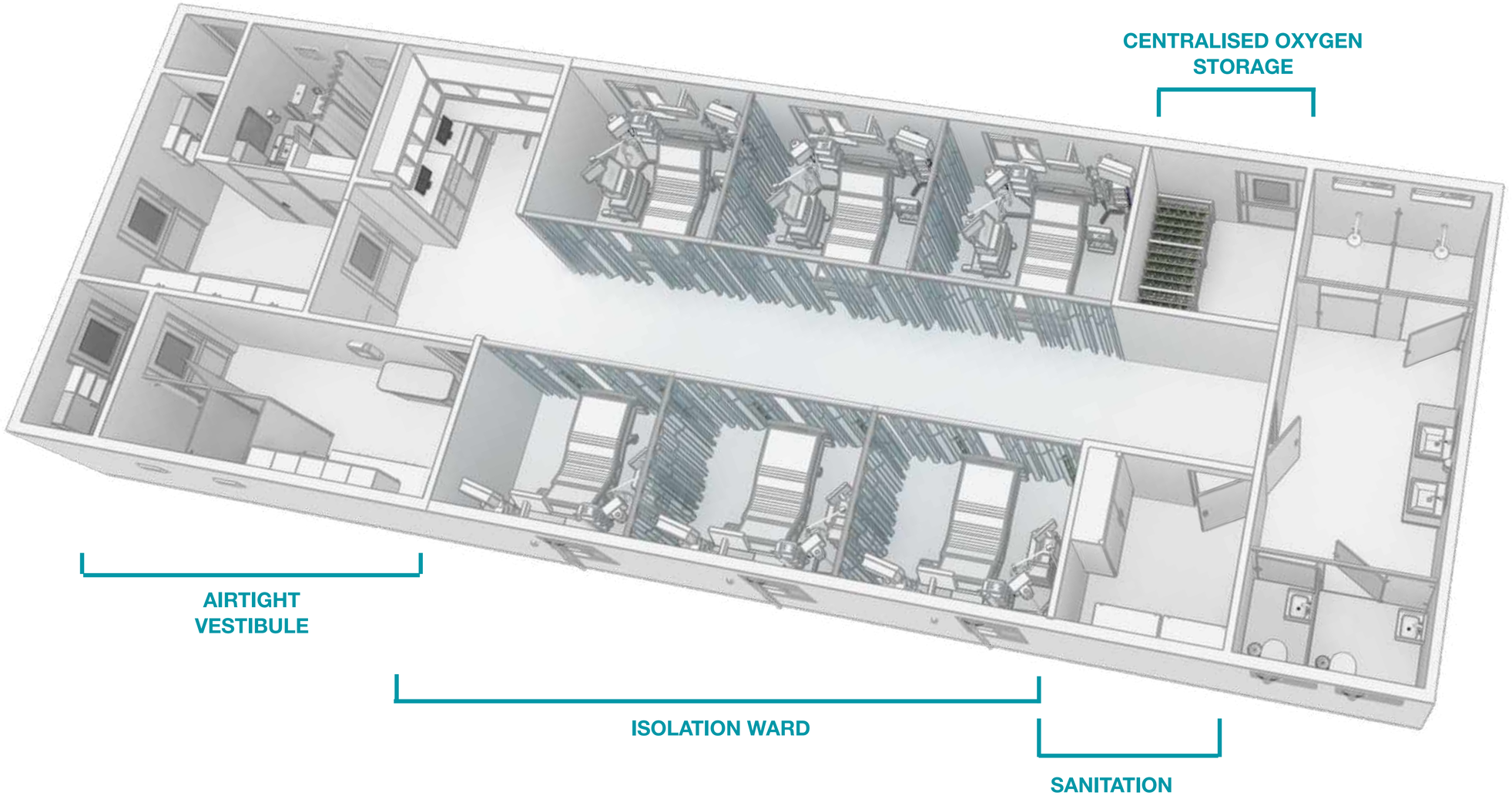


Patients with severe symptoms are required to be isolated with additional care in the form of Ventilators (with/ without splitters) - cylinders/ oxygen concentrator, infusion pump, suction devices, multipara monitor, defibrillator, ECG

No partition walls to be provided in ICU units - privacy curtains to be added.

Separate oxygen tank storage for centralised oxygen supply needs to be provided.

D. ICU (Severe Symptoms) ward - 6 Beds



Sustainable Energy driven and Climate Responsive Infrastructure for ISOLATION & THERAPEUTIC units for COVID19

D. ICU Ward-6 bed Load Details (AC/ DC Power Supply 220-240 Vac)

S. No.	Room Type	Room Name	Load Details	Specifications	Load Wattage	Quantity	Usage Hours.
1	Airtight Vestibule	Medical Personal Station	Exhaust Fan	min 130 CFM (Cubic Feet per Minute to allow 12 air changes per hour)	40-60	1	12
			LED Tubelight	48 sq. ft hospital floor area requires min 2141 Lumens with medium illumination intensity / 16 watts	20	1	10
			Mobile Charger	USB Type	10	3	4
2		Staff Change	LED Bulb	80 sq. ft bathroom area requires min 2230 Lumens with high illumination intensity/ 20 watts	10	2 (divided amoung the shower and toilet area)	3
3		Wash	LED Bulb		6	2	4
4		Dirty Utility	Exhaust Fan	min 130 CFM (Cubic Feet per Minute to allow 12 air changes per hour)	40-60	1	12
			LED Tubelight		20	1	3
			LED Bulb		6	2	3
5	Isolation Ward	6 Cubicles	LED Tubelight	80 sq. ft hospital floor area requires min 3568 Lumens with medium illumination intensity / 27 watts	24	6	7
			Mobile Charging	USB Type	15	6	3
			Exhaust Fan	min 130 CFM (Cubic Feet per Minute to allow 12 air changes per hour)	40	6	12
			Infrared Thermometer	Handheld		1	
			ICU Ventilator	with oxygen cylinder (needs 100% of oxygen and needed to regulate it with mixing of air)	200	6	24
			Multi Para Monitor	Able to measure & display ECG, blood pressure, temperature, heart rate, respiratory rate and pulse oximetry	35-120	6	24
			Infusion Pump		25-50	6	24
			Defibrillator		100	2	0.25
			Suction Machine		180	6	1
6	Sanitation Area	Toilets/ Shower	LED Bulbs	12 sq. ft hospital floor area requires min 335 Lumens with medium illumination intensity / 2 watts	6	4	4
			Exhaust Fan	min 50 CFM (Cubic Feet per Minute to allow 12 air changes per hour)	20-30	4	4
7		Wash Basin	LED Tubelight		20	1	5

Solar System Design

1. Solar powering ICU

Max Load that can be connected	3672 W
Max units of energy (kWh) usage per day	46.318 units
System Voltage	240 V

Assumptions

Sunshine hours: 5 hours

Depth of Discharge (DoD): 80%

Days of Autonomy: 1 day

Solar Panel	**22.5 kWp**
Solar Battery	**300 Ah, 240 Vdc**

Estimated Solar Cost: Rs. 20,00,000/- (Approx.)

Max Load that can be connected	3742 W
Max units of energy (kWh) usage per day	47.158 units
System Voltage	240 V

Assumptions

Sunshine hours: 5 hours

Depth of Discharge (DoD): 80%

Days of Autonomy: 1 day

Solar Panel	**23 kWp**
Solar Battery	**300 Ah, 240 Vdc**

Estimated Solar Cost: Rs. 20,00,000/- (Approx.)

Sustainable Energy driven and Climate Responsive Infrastructure for ISOLATION & THERAPEUTIC units for COVID19

Other Auxiliary Infrastructure - OPD and IPD

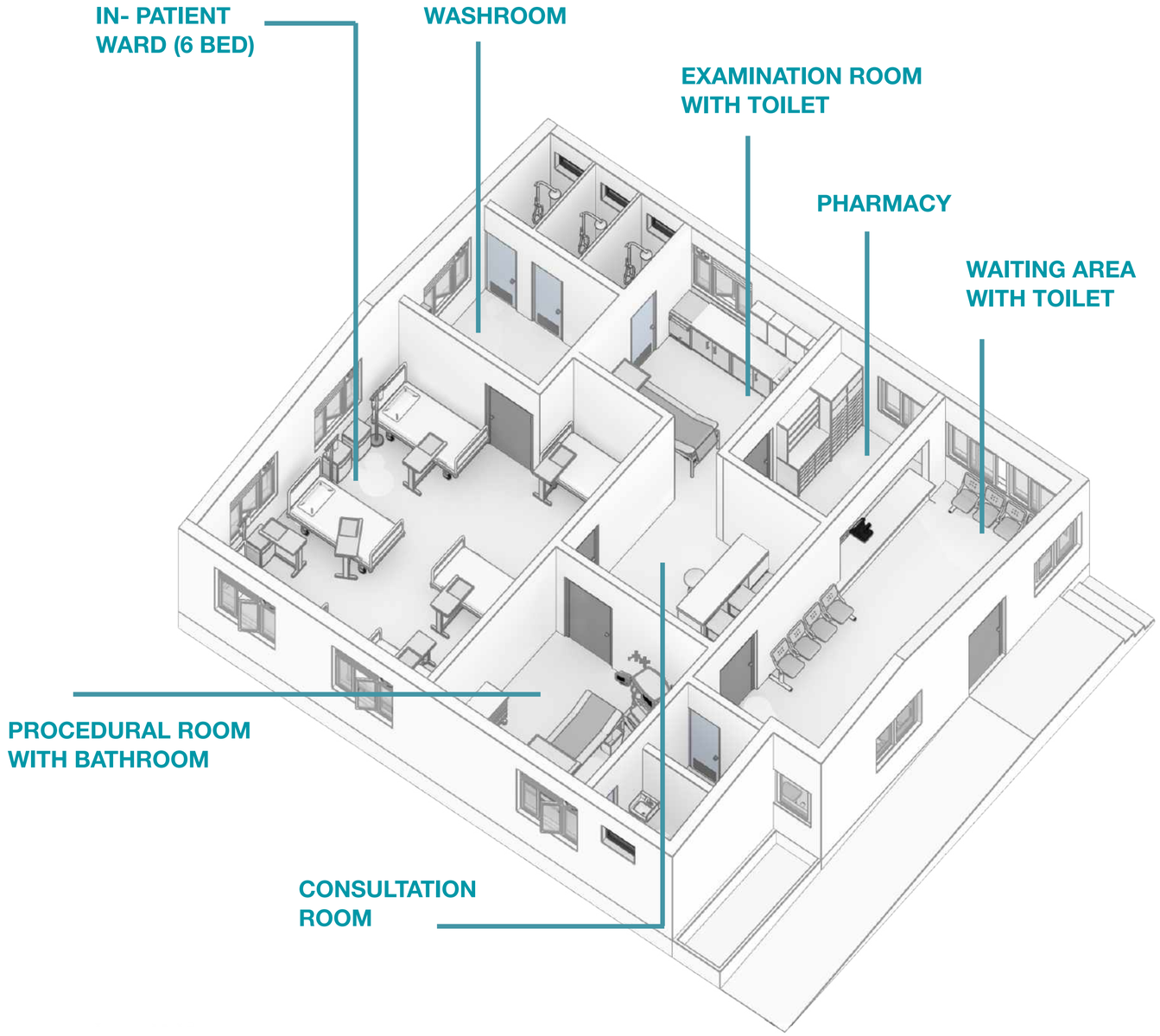
In geographies affected by the pandemic, district hospitals and speciality care hospitals are being transformed into isolated COVID-19 care designated spaces. This is done to ensure trained medical personnel are available in a centralised manner during the crisis.

In this case, care for regular patients and services to TB, cardiovascular, neurology patients need to be provided in an auxiliary infrastructure. This service could be provided by a local private hospital or Primary Health Facility, in the absence of which this can be supplemented as an add-on unit to the speciality hospital.

For such auxiliary facilities, following guidelines can be followed:

- General screening of patients should be done outside waiting area by collecting their oral health history record and thermal screening. Families of patients should be discouraged from entering the premises
- Ensure waiting room and in-patient ward follow safe distancing of 2m between patients
- Designated wash area should be provided for staff, in-patients and out-patients
- Designated procedural room for minor surgeries should be provided
- Additional IPD with washrooms and toilets can be also provided where HR support is available
- A Pharmacy with adequate medicines and cold storage facility can also be added to the module

During the pandemic - sterilisation and hygiene practice should be follow as per regulation



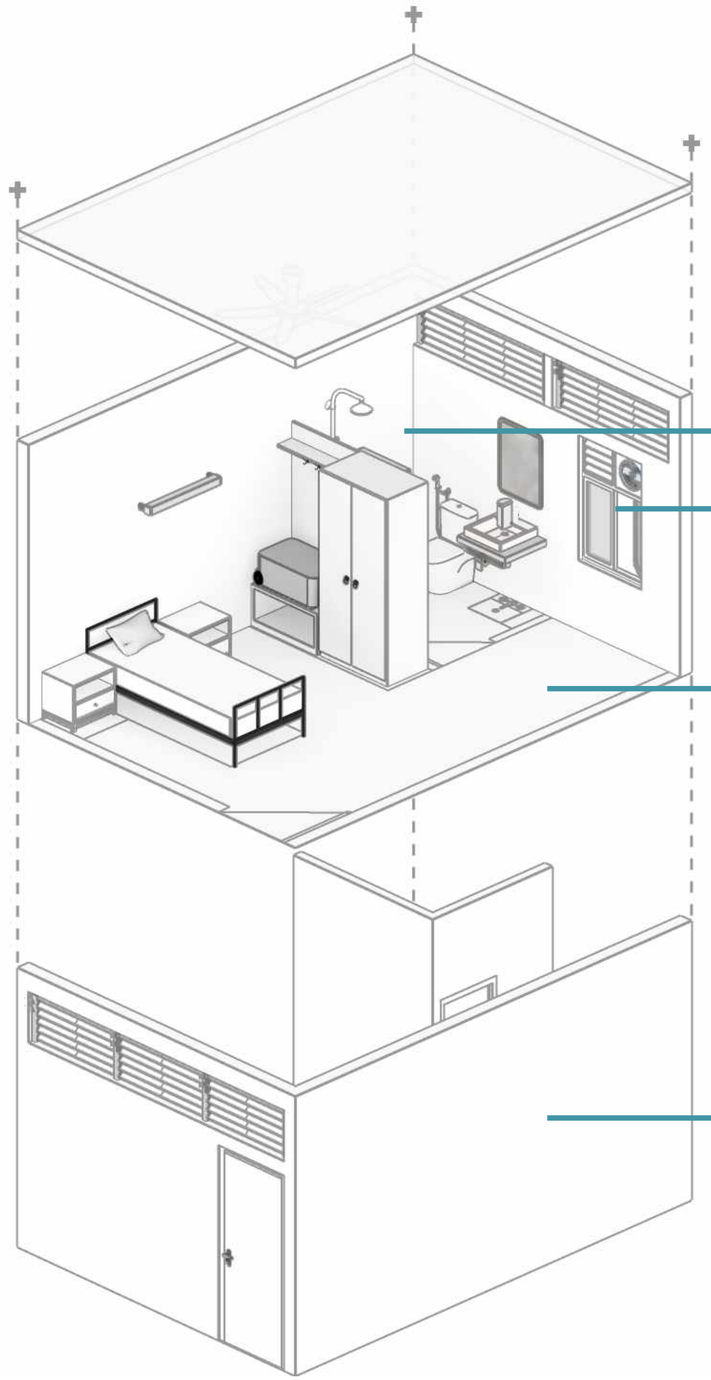
Sustainable Energy driven and Climate Responsive Infrastructure for ISOLATION & THERAPEUTIC units for COVID19

Staff Quarantine Units / Staff Quarters

It is important that well-being and safety of the staff at the COVID19 facilities, and their families is maintained. The medical staff at designated COVID19 treatment centres have been reportedly working long hours, many infected due to shortage of PPE or close contact with COVID19 infected patients. Reports have also come in on how the medical staff can also be a virus carrier themselves and precautions need to be followed when they interact with family, friends and colleagues outside the hospital.

In this case, spaces need to be provided for the staff to live in quarantine from their families, and other non COVID19 medical staff at the facility as a precautionary measure. The following protocols and guidelines should be followed in these staff quarantine units:

- General screening of doctors, nurses and other medical professional at entry and exit of the staff accommodation
- Families to be discouraged from visiting the accommodation
- Daily sterilisation or fumigation to be ensured in the facility
- Common gathering areas or cafeteria services to ensure physical distance and hygiene practices



Bathing facilities equipped with all sanitary fitting (1.8m x 1.5m)

Ample mechanisms for cross ventilation and exhaust (Window+Ventilator+Exhaust Fan)

Interior layout of a studio style apartment with allowance for 1 Bed, Table and Storage facilities (3m x 3m)

Outer Envelope - Prefabricated or In-situ methodology of construction with entry door and ventilators depicted

Sustainable Energy driven and Climate Responsive Infrastructure for ISOLATION & THERAPEUTIC units for COVID19

Typical Layout 1 (Common Corridor) 5,7,9,11… Units

The modular design shown alongside is designed to provide a safe quarantine and resting space for the medical staff in a COVID19 Treatment Facility.

Each modules is designed to have its own private toilet, with adequate natural lighting and ventilations. Depending on the space available on the site, and the requirement at the health facility, the capacity can be increased by extending the corridor and addition additional modules.

References and Acknowledgements

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https://mail.google.com/mail/u/0/?ui=2&view=btop&ver=1wti76qpozfyq#attid%253Datt_17144463f9ee9971_0.1_1408c7ee_131044d6_2b1d5ee9_1ce23556_5e822627%25252FHow-to-convert-Hospital-into-COVID-Hospital.final-pdf.pdf
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We would also like to thank Dr Umesh Badhani, Head of Department, Anesthesiology at AIIMS, Patna on providing a deeper understanding on guidelines for ventilation and thermal comfort.

SELCO Foundations role in COVID19 response and the Health+Energy Nexus

The COVID-19 crisis has alarmingly brought to front the unpreparedness of the humanity to deal with such a crisis. It also lay to bare the glaring gaps in the health supply chains across the world. Previously, the gaps were main focused on the cost of delivering health services and its inaccessibility to the poorer populations across the world.

SELCO Foundation some years ago started a Health Vertical to prove that an ecosystem approach to relook at Energy-Health nexus would be more impactful and make delivery of health more affordable, sustainable and most importantly accessible. SELCO advocated for sustainable energies like solar, in a decentralized manner, to be an enabler that could help the health sector close the gaps it was facing. Under the Energy-Health nexus, SELCO holistically evaluates, after a thorough energy-health assessment, the gaps, and maps out the specific solutions (including aspects of efqieicny, sustainable energy and green building design) to improve resilience of health centers and decrease cost per patient care over time. The integrated approach has led to better building designs, more efficient and modular medical equipments, decentralization of services, better human resource retention and mapping, effective use of technology and a more customized approach the health.

SELCO hopes the nexus approach will not only integrate sustainability into the health sector in a deep manner but also help the respective stakeholders a faster way to reach the sectors goals.

For more information:
Write to: covid19@selcofoundation.org
Or Visit: covid-19.selcofoundation.org