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The Development of a Generic Design for Primary Healthcare Facilities in South Africa

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Abstract

Primary healthcare (PHC) service delivery is severely hampered by lack of, and poor quality infrastructure. In many cases the physical infrastructure at clinics is old, inadequate and in some cases not suitable for use. The provision of services (water, sanitation and electricity) is in many cases not adequate, especially in rural areas. This study developed a generic design for modular conventional clinics and for rapid deployment clinics. Researched, patient-centric service delivery and workflow have been used as major drivers for design configuration. Clinics have been organised to accommodate three patient streams: namely chronic services, acute services, preventive and promotive services. An optimal patient flow pattern was determined and the infrastructure norms and standard guidelines developed by the South African National Department of Health were considered. The space requirements were derived from the design terms of reference and the PHC norms and standards. Two methods of construction were assumed, i.e. traditional brick and mortar, and Innovative Building Technology (IBT) system with the latter being an insulated panelised system. A conceptual design for a generic, basic clinic for use in South Africa is developed. The conceptual design is modular based and allows for additional functions to be added as and when required. The design is both flexible and adaptable. It is highly likely that the clinic may function off-grid under certain circumstances.

Keywords: health infrastructure, basic clinic, building services

1. Introduction

Recognising that historical funding models have entrenched inequity and undermined affordability of healthcare services in South Africa, the South African National Department of Health has introduced the National Health Insurance (NHI) scheme to integrate healthcare services. This requires a "re-engineered approach to providing primary health care (PHC) using a population based approach for the delivery of PHC outreach service to the uninsured population of South Africa" (NDoH 2011:2). Major implications, such as shifting to increased community outreach services (as opposed to facility-based services), and emerging requirements for information networks (for NHI management) are foreseen. As infrastructure is integral to the delivery of healthcare services, these organisational transformations provide an extraordinary opportunity for science, engineering and technology input across the life cycle of primary healthcare facilities.

Primary healthcare (PHC) service delivery is severely hampered by lack of, and poor quality infrastructure. In many cases the physical infrastructure at clinics is old, inadequate and in some cases not suitable for use. The provision of services (water, sanitation and electricity) is in many cases not adequate, especially in rural areas. In addition to this, no standardised clinic design and lifecycle management tools currently exist. This results in poor infrastructural investment decision making, problematic procurement processes and practices and poor maintenance of existing facilities. Re-engineering of primary healthcare as the main mechanism of healthcare service delivery requires urgent intervention at the infrastructure level.

This study developed a generic design for modular conventional clinics and for rapid deployment clinics. The study does not evaluate materials that could be used or undertake a comparative analysis between materials. This study focuses on the components underlined in Chapter 3.

2. Research approach and methodology

Designers of buildings are often unable to explain how they arrived at a design solution beyond "that his or her reason for making a particular design decision is based on a 'feeling' or 'intuition'" (Wiggins 1989:1). However, increasing building complexity and sustainability imperatives require a "new decision model" (Mendler and Odell 2000:19; CIB 2009:4). Mendler and Odell (2009:24) argue that this new approach "requires some focused research time" and that sustainable design "requires the design team to consider a larger number of issues in the decision-making process" with "supplemental research to understand the environmental impacts associated with design options and to identify preferred approaches". It can be argued that what is being proposed is the use of grounded theory being "a set of rigorous research procedures leading to the emergence of conceptual categories" which may make use of both quantitative and qualitative data (GTI 2015).

The research approach to the study was based on the South African Institute of Architects (SAIA) *Plan of Work* as proposed in their Practice Manual (SAIA 1.1211:3). The Plan of Work consists of five work stages namely:

Stage 0 – Inception briefing and appointment of consultants
Stage 1 – Appraisal and definition of the project
Stage 2 – Design concept
Stage 3 – Design development
Stage 4 – Technical documentation and approvals
Stage 5 – Contract and administration and inspections

This study includes only Stages 1 and 2.

A reading of the practice manual Plan of Work may suggest that the two work stages actually imply a research-based approach to design: however the text is biased towards meeting the programmatic goals of the client rather than researching the full range of performance requirements of the building project.

The research method used by the study is Ernst Neufert: Architects' Data (ed. Herz, 1970) as it suggests a methodology closer to research-based design and uses qualitative and quantitative research data. In the section appropriately titled 'Design Method' (Herz, 1970:30) it is recommended that the “work starts with the preparation of an exhaustive brief” and lists information that must be known before planning begins. The required information includes site (location, environment, size, levels, services, fixtures); space requirements (areas, heights, positioning and relationship); dimensions of existing furniture; finance (site acquisition, legal fees, mortgages, etc.,); proposed method of construction (brick, frame construction, sloping roof, flat roof); and all the legal facts. A questionnaire is included in this approach which includes questions relating to the client, fees and agreements, persons and firms connected with the project, general, project, basic design factors, technical fact finding, records and preliminary investigations, preliminaries, and activities and events. The question is a combination of quantitative data (e.g., type of topsoil) and qualitative (e.g., what is the attitude of the town planning officer towards architecture).

It then recommends that the individual units are analysed, drawn to scale and put provisionally into groups. The relationships of rooms to each other and to the sun are analysed (Herz 1970:30). What follows is critical: ‘at this stage an “idea” in 3-dimensions will emerge’ and ‘instead of starting to design at this stage, explore the various means of access, the prevailing wind, tree growth, contours, aspect, neighbourhood, then finalise the positioning of your building, relating it to tentative landscaping, etc.’ Finally, it recommends that one ‘try out several solutions to explore all possibilities and use their pros and cons for searching examination.’ Based on the foregoing it argues that the ‘idea now becomes clearer and the real picture of the building emerges’.

What is described in Neufert’s text is grounded theory, a research method that aims to allow the theory (in this case the idea) to emerge from the research. In fact, an early attempt to ‘design’ is discouraged to allow theory testing to be done from which a ‘design’ emerges. Further evidence to support this theory is found later: Neufert recommends that after the completion of the preliminary design a pause is taken to ‘help get rid of preconceived ideas and undigested brain-waves, and to allow time for other short-comings of the design to be revealed not least in discussions with staff and client’ (Herz 1970:30).

To further aid this research method Barry’s Introduction to Construction of Buildings (Emmitt and Gorse, 2005) is used to construct a useful methodology for considering the construction of buildings by breaking the construction process down into five basic components, namely; sub-structure, super-structure, roof assembly, services, and finishes. Each of these components can be further sub-divided into sub-components such as windows and doors for super-structure. This approach has been used with some success in previous experimental studies undertaken by the CSIR at its Innovation Site in Pretoria (van Wyk, 2009; de Villiers 2011).

3. Research question and sub-questions

The primary research question is the following:

How and in what way can Science, Engineering and Technology (SET) give input into the development of a standardised design terms of reference, based on a modular approach, for a basic clinic that will comply with primary healthcare (PHC) norms and standards while delivering improvements in indoor environmental quality, reductions in non-renewable resource use, improved construction quality, reduced construction time, reduced construction cost, and support resilient human settlements in a sustainable and economical manner?

In order to answer the primary research question, a number of sub-questions must be answered. Not all of these sub-questions are addressed in this paper: the sub-questions addressed in this paper are underlined in the primary research question.

4. Standardised design terms of reference

Researched, patient-centric service delivery and workflow have been used as major drivers for design configuration. Clinics have been organised to accommodate three patient streams: namely chronic services, acute services, preventive and promotive services. Care is taken to provide general zoning which allows for future expansion, particularly for specialised services, community outreach services, and the patient streams, where greatest future growth is anticipated.

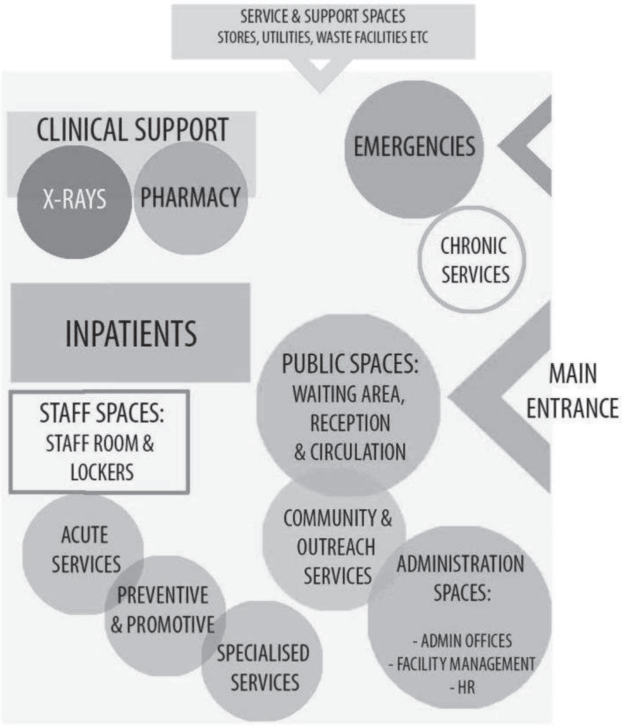

Figure 1: General zoning

4.1 General ambulant patients

Patients enter the clinic site through a controlled entrance at the security guardhouse. From here they proceed to the front entrance of the clinic building. Upon entering, patients are triaged and except for emergency cases, register at the front reception desk. Thereafter they remain in the main waiting area until called by the nurse who, where necessary, takes the patients' details, blood pressure and possibly their weight. Patients required to give a urine sample for testing will use the universally accessible ablution facility adjacent to the sample room. Having been attended to by the nurse, patients are directed to wait in the sub waiting area before proceeding to the relevant room. After consultation or counselling, patients either go to the treatment room for further assistance, collect medication from the dispensary or leave the building.

4.2 Emergency patients

Patients requiring urgent care are triaged on arrival and are immediately directed to the emergency room where they are attended to by the nurse who may arrange to transfer the patient to a referral hospital.

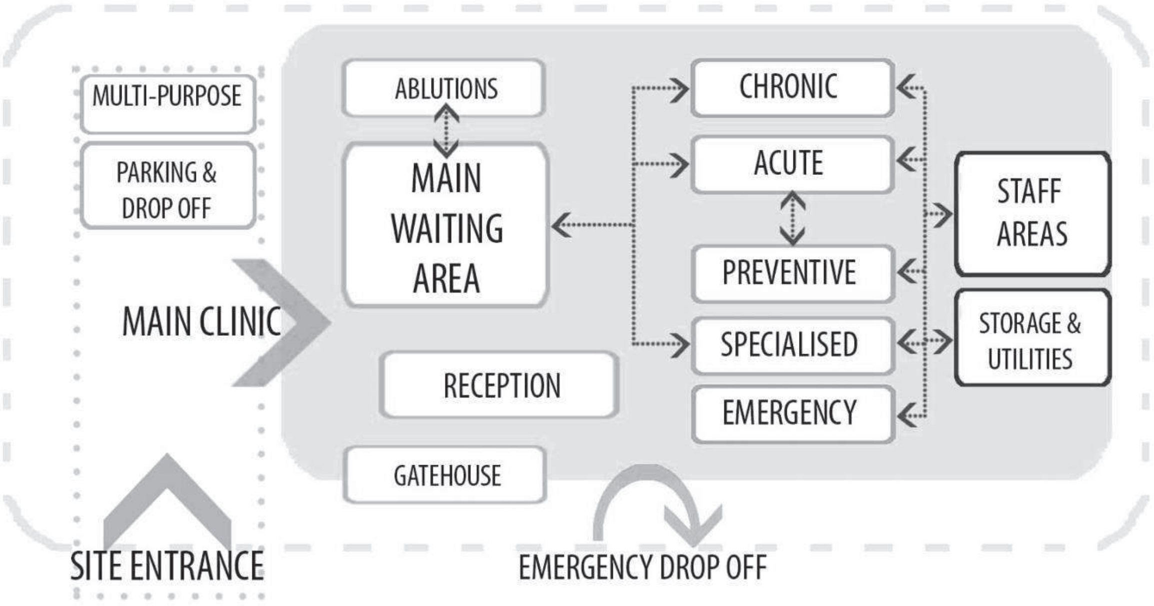

Figure 2: Functional Relationships for Basic Clinic

5. Norms and Standards

The development of guidelines, norms and standards formed part of a National Department of Health project called Infrastructure Unit Systems Support (IUSS Project). IUSS was a structured collaboration between the National Department of Health (NDoH), the Development Bank of Southern Africa (DBSA), the Council for Scientific and Industrial Research (CSIR), and other stakeholders with the shared objective of optimizing the acquisition and management of South Africa's public healthcare infrastructure throughout the infrastructure's lifecycle.

The development of guidelines, norms and standards has been structured into work package sets and 45 work packages including facilities and departments, regulations, engineering services, infection prevention and control, equipment, sustainability and environment, tomorrow's healthcare environments, have been identified. A development programme has been initiated providing for input focused workshops and output focused task groups developing new draft documents.

The draft norms and standards developed for the IUSS Project have been used to prepare the concept design.

6. Modular requirements

The intention is to develop a generic basic clinic design that can be constructed using either conventional building technology (brick and mortar) or innovative building technologies (IBTs).

In both instances use has been made of a modular approach based on a modular dimension (modules of 300 mm) creating a standardised unit capable of being fitted out to serve the specific function, and have interchangeable components (doors, windows, etc.). This approach was taken to ensure that the clinic was flexible enough to adapt to local conditions and could be scaled-up to meet local needs over time. The modular approach was also applied to the design and selection of off-grid utility services, especially electricity generation (solar and wind) and sanitation.

Having regard for the patient flow and norms and standards a modular dimension of 4.2m x 3.0m created the most flexibility. In the conventional building technology application the foundations will be conventional concrete foundations and slab: for the IBT application a steel chassis will be constructed with steel supporting super-structure and roof. The IBT module will be manufactured in the factory and transported to the site where it will be placed on supporting stub columns (brick or concrete).

In both IBT cases the interior can be equipped according to its intended use either off-site, or on-site, depending on the circumstances of the specific project.

7. Non-renewable resource reduction

Buildings and their operations depend on the continued supply of services such as water, sanitation and electricity. However, service delivery failures do occur whether due to design and operational factors such as regular maintenance or system failure. An assessment of infrastructure in South Africa in 2011 noted that "the quality and reliability of basic infrastructure serving the majority of our citizens is poor and, in many places, getting worse" (SAICE 2011:5). Of the three services targeted in the study namely, electricity, water and sanitation, the infrastructure report card finds that there has been "further deterioration in the ageing bulk water infrastructure portfolio as a result of insufficient maintenance and neglect of ongoing capital renewal" with water quality identified as "a serious problem, especially outside metros" (SAICE 2011:6), "serious problems with management of many waste water (sewage) treatment works" including "waste water leakage and spillage, especially into major rivers" and that the backlog in sanitation "increasing owing to unsustainable infrastructure", and with regard to electricity that "in many areas infrastructure is ageing and/or overloaded" with municipal infrastructure in particular described as "below standard and poorly maintained (SAICE 2011:8).

Critical services such as primary healthcare rely on a stable service provision especially with regard to water, sanitation, electricity and the proper storage of drugs. Innovative infrastructure service technologies are technologies that can be implemented to provide alternative methods for securing a stable infrastructure service.

One of the strategies that can be employed to ensure an uninterrupted service is to reduce the building's exposure to municipal services through the use of innovative infrastructure technologies. This has a number of benefits: first, it assists the building to adapt to major perturbations and events without a disruption in service delivery; second, reducing the building's dependence on municipal services also reduces the operational costs of the building; and third, innovative infrastructure technologies are less resource intensive, especially with regard to the water/energy nexus, as they operate at the site of use, thereby reducing the requirement to move bulk services around.

7.1 Energy

It is intended that all the power required to operate the building should be generated on site allowing the building to function off-grid. As the building is to be used primarily as a clinic facility, the design demand should be calculated on maximum demand when the building is being fully utilised. Based on an analysis of the expected demand for electricity, a load profile was generated using the expected utilisation of appliances. The daily average power consumption of the clinic was calculated as 19,8kWh/day, i.e., an electricity generation system that is sized to produce 20kWh/day is required. The cost of a 20 kWh/day PV system for a sunny but wind poor location such as CSIR Pretoria campus ranges from R291,718.00 to R319,000.00 inclusive of VAT and requires 48m^2 of PV panels. The cost of a 20 kWh/day wind system for a windy location such as the East London Industrial Development Zone is R287,854.56 inclusive of VAT and requires 2 x 3kW wind turbines. Preliminary investigations indicate that a wind system is slightly cheaper than a PV only system, but is site dependent on the availability of wind and solar resources.

The following three options were recommended, each one capable of being up-scaled using the modular approach, for the clinic to function off-grid:

- Photovoltaic (PV) based system for the generation of electricity for sunny but wind free sites such as CSIR Pretoria campus.
- Wind based system for the generation of electricity for windy sites such as the East London Industrial Development Zone.
- Liquid Petroleum Gas (LPG) for heating and cooking.

7.2 Water

Standard setting for water and sanitation at clinics takes place within specific dimensions of quality - acceptability, accessibility, appropriateness, continuity, effectiveness, efficiency, equity, interpersonal relations, technical competence and safety. Different kinds of facilities will be required to provide the same services in different situations, for example services to clinics in remote rural areas will be provided through different facilities compared to polyclinics in high-density urban areas. Therefore national standards about facilities and staffing norms for clinics are not set. The National Department of Health defines what services and facilities are required to best meet the health needs of the nation, i.e. a clinic must have a supply of electricity, running potable water and proper sanitation, which means adequate number of toilets for staff and users in working order and accessible to wheelchairs, but do not specify how the services are to be provided and at what level the standards should be met.

Clinics, especially in rural areas, tend to become a social gathering point for the communities, mainly because of the general lack of infrastructure (electricity, water sanitation, roads, transport, etc) compared to clinics in urban areas. The person-load per day of rural clinics is therefore generally higher than that of urban clinics, as patients normally have the responsibility of caring for a number of children/family, or are too old, or disabled, to visit the clinic by themselves and need assistance, and as transport services are infrequent, long waiting periods.

Water conservation includes rainwater harvesting and treatment, and waste water recycling systems. Rainwater harvesting, in its essence, is the collection, conveyance and storage of rainwater. The scope, method, technologies, system complexity, purpose and end use vary from rain barrels for garden irrigation in urban areas, to large-scale collection of rainwater for all domestic uses.

In the case of this clinic design, rainwater is collected and stored in rainwater tanks: the tank or tanks can either be positioned on the ground close to the downpipes or in a single more ideally situated location, or buried in the ground as a subterranean tank. The number of people being served at the proposed clinic estimated at 1400 per month. The recommended water allowance per person per day use as recommended in the World Health Organization guidelines is 2 to 6l/d (WHO 2011:9.2). The water demand per month will range between a lower limit (1400 x 2 x 22 = 61600) and the upper limit (1400 x 6 x 22 = 184800). No provision is made for urinals and the water closets (wc's) are based on closed-system units described more fully under sanitation. Using Pretoria as the location of the clinic, and given the area of the building (300 m^2) and the annual rainfall (732mm) (Climatemps 2015) the expected maximum annual harvested water supply will be 219600 liters which is insufficient to meet the needs of the clinic. Additional water sources will be required including sustainable urban drainage systems (SUDS) which will be very site-specific.

7.3 Sanitation

Lack of sanitation in healthcare facilities appears to be a more serious matter than lack of water supply. Many factors influence the choice of sanitation technology that meets the requirements for adequate sanitation at clinics, and these include:

- Cost effective provision of services and accessible to maintenance and servicing of the toilet by local community members.
- Management - The choice of system that is sustainable over the years.
- Use of the local contractors targeting youth and women.
- Sustainability of employment for the operation and maintenance.
- Improvements to health.

If a water supply is available, a conventional water-borne system can be selected, but many rural clinics have an erratic water supply that is inappropriate for the provision of water-borne sewage systems. In the case of insufficient water supply the choice of sanitation facility is usually limited to a dry on-site system, whether a VIP or waterless system, or a closed-loop recycling system. On-site, close-loop system, flush toilet waterborne sanitation systems are available from a number of companies and manufacturers in South Africa. They are ideal sanitation solutions in cases where only dry sanitation was an option. Generally in these systems naturally-occurring micro-organisms (bacteria) are selected as a biological additive to the digester tank. The biological process occurring in the digester tank converts raw sewage into re-usable filtered water, ready for re-use to the toilet cistern for flushing. A solar panel is installed to power the recycle pump in the digester unit. The product can be supplied as a pre-assembled unit or it can be supplied in a kit form to be assembled on site. This makes the transport of the unit much easier and no heavy equipment is needed for installation. The parts can easily be handled and carried by hand.

8. Concept design

From the above data a concept design was generated. Using the design approach advocated by Neufert (Herz 1970:30), the design commenced by the preparation of an "exhaustive brief". This was obtained from the patient flows and the PHC norms and standards. No specific site was identified so the assumption was made that the site is accessible on all sides, is flat, and is north orientated. It was assumed that no services are available. The space requirements were derived from the design terms of reference and the PHC norms and standards. It was assumed that finance would be made available from Government. Two methods of construction were assumed, i.e. traditional brick and mortar, and Innovative Building Technology (IBT) system with the latter being an insulated panelised system.

The second phase of the concept design analysed all the individual units, drew these to scale, and arranged them in groups (see the plan sketch in Figure 3). From the 2-dimensional floor plan a section was generated (see section in Figure 2). This was the outcome of a number of "solutions to explore all possibilities and use their pros and cons for searching examination" (Herz 1970:30). A number of assumptions were used to generate the section. First, the building is raised to enable displacement ventilation to occur. An overarching roof was generated to provide additional shade to the rooms below, and to enable the extraction of air from the rooms. Preliminary ideas around the fitting of photovoltaic panels and solar water heaters are explored, as well the fitting of a rainwater harvesting system. The potential to open and shut the rooms is also explored to aid ventilation and security after hours. The section was the first attempt of a "real picture of the building emerging". From the plan and the section a 3-dimensional sketch could be generated (see Figure 3).

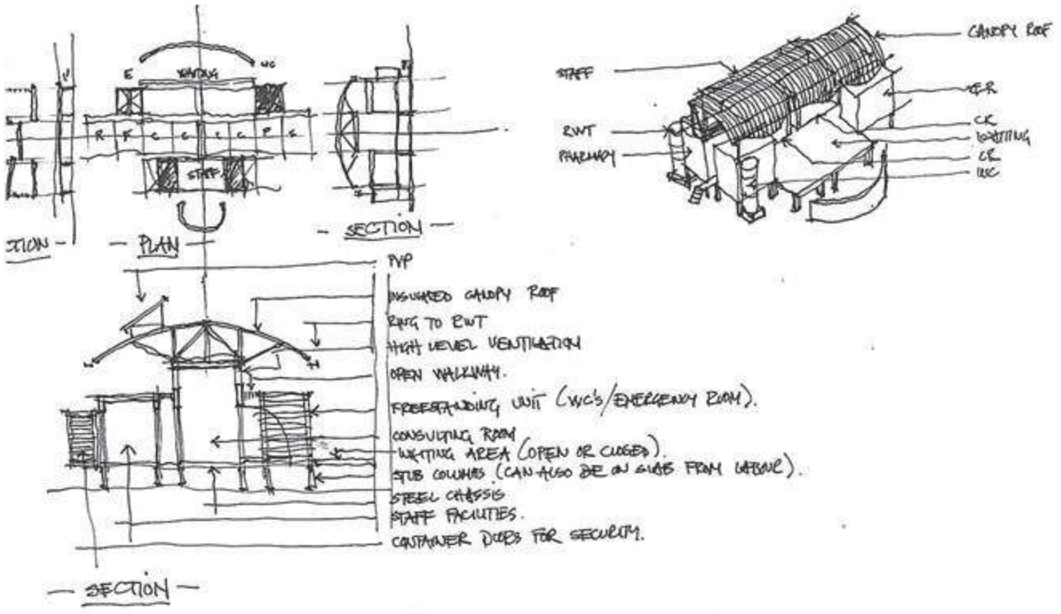

Figure 3: Design sketch

As already indicated above, this sketch was the outcome of a number of iterations. Further to Neufert, "a pause is taken to help rid of preconceived ideas and undigested brain-waves, and to allow time for other short-comings of the design to be revealed not least in discussions with staff and client (Hertz 1970:30).

The outcome of this period of reflection was the further development of the design as shown in Figure 4.

Figure 4: Conceptual design for basic clinic

9. Conclusion

The study developed the basis for a generic basic clinic for application in South Africa. The conceptual design is modular based and could be constructed using either conventional building technologies (brick and mortar) or Innovative Building Technologies (IBTs). The conceptual design also allows for additional functions and its supporting infrastructure to be added as and when required. The design is therefore both flexible (the modularity allows rooms to be used for different functions should the requirements and needs change) and adaptable (may be extended in a number of ways).

The research finds that it is highly likely that the clinic may function off-grid under certain circumstances with the exception of water where approximately half of the required demand can be met off-grid. These circumstances relate to climatic conditions, topography of the site, location of the site, ground conditions, and the extent of the site.

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