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## SUSTAINABLE MATERIALS AND ELEMENTS IN LOW COST HOUSING IN NORTH CENTRAL NIGERIA

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### Abstract (10pt)

The basic need for human being is shelter. The hitch of shelter is a major concern in Nigeria sequel to high population, where a major challenge for tenants is the high cost of housing. The city capital of Nigeria known as Abuja, located in the north central region will be considered for the purpose of this paper, as the study will assess housing affordability challenges and media of achieving low energy consumption in the low cost houses including the utilization of natural materials in the construction phase, because occupants well-being, productivity and efficiency is defined by low living cost and indoor thermal comfort.

North central Nigeria, having a tropical wet and dry climate with its high temperatures and intense solar radiation, is becoming hotter and drier in this era of climate change and global warming. Solar water heating and the rainwater harvesting system will be considered to achieve affordable housing of good quality within the urban poor. These elements are widely recognized as an essential method of creating sustainable built environment especially in the context of developing world cities. The paper will proffer possible ways low cost housing can be achieved through simple change and amendments to the current practices.

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### 1. Introduction

To produce a low cost housing has always been a major challenge in the construction industry in spite of government interventions in the provision of affordable housing. In Nigeria, housing started for long before the country's independence, yet a large percentage of its citizens still live in very bad conditions [1]. The provision of adequate shelter is a necessity and important to the well-being as well as survival of human beings [2]. These can be achieved towards a sustainable housing approach.

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Sustainable development is an activity that “fulfill the needs of the present without compromising the ability of future generations to meet their own needs” [3]. Sustainable housing development provides a framework for the integration of environmental policies and development strategies. The sustainable residential design is made to lessen environmental impact and to improve environmental quality [4]. The idea of sustainable housing development initially focused on issues such as inadequate resources, especially energy, and how to reduce environmental effects on the natural surroundings. Sequel to these needs, sustainable housing development can be considered as a helpful means to protect natural resources and provide a cheap and affordable cost throughout the lifecycle of a building by using energy efficiency parameters to minimize energy consumption [5] [6]. Architecture today has been almost universally designed in terms of energy efficiency performance. Suitable vernacular design of elements are incorporated into a building, which will improve its energy efficiency and as well comfort [7].

Thus, global efforts at meeting human needs for shelter found expression in its inclusion among the objectives of sustainable development program. Thermal comfort in residences, as well as providing a low living cost housing in north central Nigeria where the federal capital (Abuja) is located is a major task at hand. In order to achieve a real affordable house which is cost and energy efficient, sustainable building materials and elements would be considered, in light of the difficulties experienced in having access to portable pipe borne water and lack of constant power supply, Rain water harvesting system and solar water heating would be the main elements to be discussed as it will take advantage of high amount of annual sunshine and rainfall recorded in this region. Also the potential of making the appropriate choice of building materials that are sustainable will be considered because the sustainable elements alone without considering sustainable materials and other passive design strategies will not give the required outcome of a sustainable development.

Generally, Nigeria like any other developing country is faced with challenges within the urban housing sector, thus many attempts to solve the challenges of low income housing by governments have failed over the years [8]. In order to cope with such challenging issues, informal housing units are erected, forming the slums and tenement settlements that often in the scenery of major cities around the world. It's now a fact that the vast majority of the world's homeless and poorly sheltered reside in developing countries that lack the resources and technology required to take a large scale action, housing conditions are seriously deteriorating and conditions are at their worst in major cities of most developing countries [9]. Even after making certain provisions, the challenges of thermal comfort and the cost of servicing these houses becomes a major challenge as much power is needed for water heating using electric water heaters and a major issue of inadequate pipe borne water with little or no alternatives is most cases.

At the end of the study it is expected that a great amount of knowledge would be acquired which will foster quality, affordable and sustainable housing schemes in future low-cost housing projects. Relatively, these parameters can improve economic sustainability imperatives such as life cycle costs and housing affordability. For example, the solar water heating or the application of lighting choices to save energy can reduce energy consumption. Less energy consumption not only means reducing the cost of required energy, but also results in increased affordability of housing. According to EERE (2010), houses in the U.S.A. are highly insulated and solar water heating, as well as photovoltaic is added on top [10]. As such, implementing the concept of sustainable development, user participation in the process, innovative design methods that include; design for the local climate, culture and economy. Thus providing for indoor thermal comfort and reducing energy use in buildings is becoming increasingly difficult. This has called for new ways of thinking and re-evaluation of the existing methods of tackling this problem.

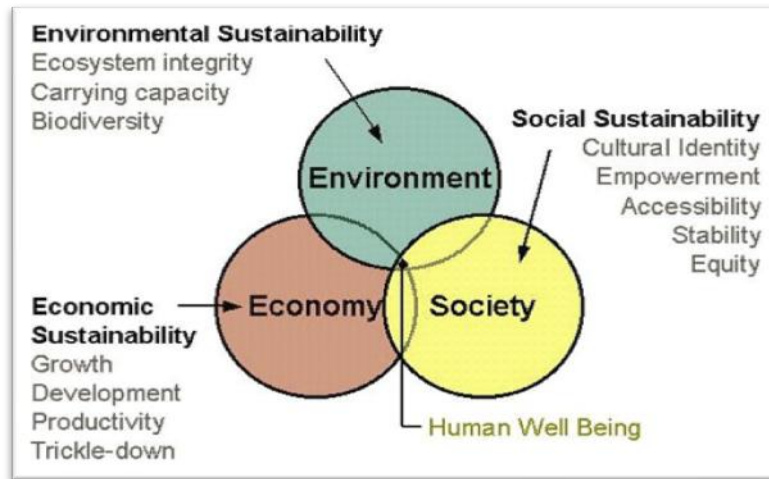


Figure 1. *Three Themes of Sustainable Development (source: BEER, 2000)*

### 1.1. Description of Study Area

Abuja is the capital city of Nigeria, in the north central region of the country. It is the city skyline, featuring a tropical wet and dry climate with a warm and humid season and an intense dry season. Precipitation measure 1.221, 2mm on average. The dry season is experienced from November to March, associated by a scorching heat, clear skies and occasional sandstorms caused by the harmattan wind. Hot temperatures reads around 35°C (95°F) and low temperature around 15°C (59°F), meaning large temperature variations between day and night. The warm and humid season lasts from April to October and is characterized by sweltering days, cool nights and pouring rain. Days still have highs around 30°C (86°F), but the feeling of the heat is much stronger, due to very high relative humidity

### 1.2. Objectives of the study

This study intends to establish and bring to fore sustainable construction practice to both the government and professionals towards achieving a low cost and energy efficient housing design. It addresses a relatively neglected area of research in the building industry of Nigeria. This is partly due to inadequate housing policies, limited knowledge and understanding due to perceived high cost of implementation and integration of sustainable elements required in the building industry. This paper aims to determine the challenges and prospects for low-cost housing within the context of sustainability by investigating the social, economic and environmental aspects of sustainable housing developments. In the context of the topic discussed, the major goal of this study is to come up with strategic recommendations that will facilitate the quality of sustainable development of low-cost housing in Abuja

## 2. Research Methodology

For the purpose of this paper, data for the study was carried out through case studies, questionnaires, observations and photographic prints. Abuja been the largest city in the north central was considered due to the prominence of modern building materials used in these cities. Residential buildings exhibited the use of modern materials in enhancing thermal comfort under the changing climatic challenges which still do not meet the tenants need, hence, alternative methods were proposed with much consideration of the natural environment including analysis of the high energy cost required for comfort. These elements demonstrated the application of sustainable building materials in adaptation of buildings to climate change scenario in their environment and the basic needs for living as it will be discussed under the findings and discussion section.

## 2.1. Sustainable Building Materials

Sustainable building materials and elements seeks to minimize the negative environmental impact of buildings by efficient energy use and moderation in the use of materials, and the ecosystem at large. Sustainable building materials should be materials that can be recycled from waste in an energy efficient method, they should have a minimum energy consumption and mostly depend on the use of Natural materials like stone, lime, sand and bamboo as well as materials that require less energy consumption for their production [11]. For instance; The 'Hydraform', which is environmentally friendly as blocks are produced under high compression from subsoil, without the need for the fuel-wood used to burn bricks. The material is characterized with excellent thermal capacity (the ability to absorb and hold heat) characterizes the blocks

Furthermore, materials found within the locality of the construction should be selected in order to minimize transport costs, more so, the longevity, durability, and maintenance costs must be kept to a bare minimum since it defeats the purpose of standard yet affordable housing if major renovation expenses are incurred as soon as possible.

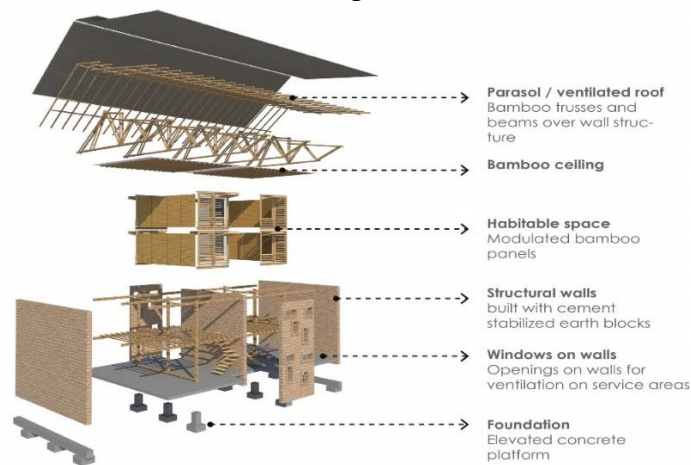


Figure 2. Showing a simple development by the utilization of sustainable materials  
(Source: <http://pr2013.aaschool.ac.uk/SUSTAINABLE-ENVIRONMENTAL-DESIGN/Self-built-Social-Housing>)



Figure 3. Sample Unit of Nigerian Army Retired Officer's Quarters showing material of wall construction

## 2.2. Sustainable Building Elements

Thus, the selected sustainable building elements considered in this paper having considered the weather and climatic condition and as well the economic and social factors of the north central region of Nigeria includes;

2.2.1. Rainwater Harvesting system in residential buildings involves the direct collection and storage of the rain water in surface or the underground water storage system for domestic uses. It entails the accumulation and deposition of rainwater for reuse on-site, rather than allowing it to run off. Rainwater can be collected from rivers or roofs, and in many other places, where the water collected is redirected to a deep pit (well, shaft, or borehole), a reservoir with percolation, or collected from dew or fog with nets or other tools. It can be also utilized to water gardens, livestock, for irrigation, and much more, with proper treatment. The general installation cost of the rainwater harvesting system is lesser than conventional water pumping and purification systems, and it requires very little energy for maintenance purposes all with the intention of collecting water that may even be used in substantial ways without purification. Although the initial cost of installing this system ranges between \$200 to \$2000, the benefit from the systems may be derived after a period above 7 years of installation all depending on the average rainfall through out the year and as well the system sophistication [12].

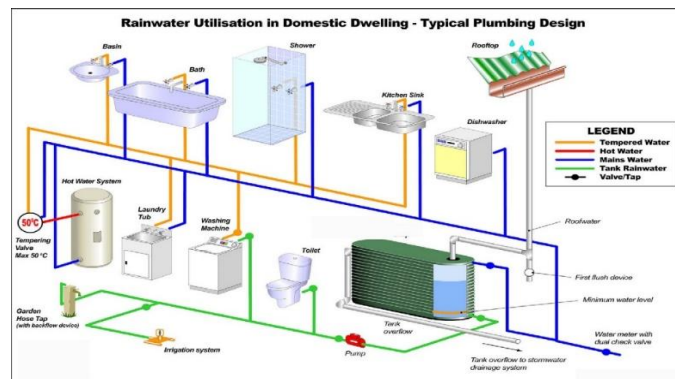


Figure 4. Showing how the Rain Water Harvesting System works.  
(Source: [http://www.dewater.com/water\\_recycling/greywater.html](http://www.dewater.com/water_recycling/greywater.html))

2.2.2. Solar water heating (SWH) entails the utilization of solar thermal collectors for the conversion of natural sunlight into heat energy for water heating. Variable configurations are available at respective cost to fit in different climates and latitudes. SWHs are widely used for residential and some industrial applications. Domestically, without water life would be pretty miserable. This system provides an option for the high amount of energy needed for water heating, as it is believed that 18% of domestic energy is utilized for water heating [13]. The initial installation cost is required, which inturn saves 50% to 100% on the utility bills, but it may take a period of three to five years to pay back relative to the installation cost and depending on the annual sunshine.

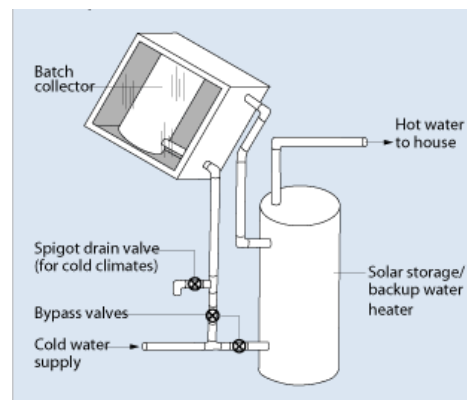


Figure 5. Showing how the Solar Water Heating system works  
Source: <http://solarheatcool.sustainablesources.com>



The system entails solar collectors and water storage tanks, which are generally divided into the active solar water heating that includes water controls and circulation pump and also the passive solar water heating which does not include controls and circulation pumps [14]. For the purpose of the low cost housing schemes the passive solar water heating is recommended because they are less expensive, and they are more reliable but not as efficient as the active system but can still serve the purpose in a low cost housing schemes

### 2.3. Case Study

Case study involves analysis of collected data from questionnaires and oral interview of respondents and pictorial illustrations. In addition theoretical descriptions of a selected study area. Descriptive statistics were used for analysis; this creates an avenue for easy deduction to be done.

The Jibi low-cost housing scheme which is a police quarters is located about 33 kilometers away from the city center was considered as a case study. It was built to accommodate the low-income indigenous staffs of the Abuja administration and Federal government, whose houses were marked for demolition, but it was later transferred to the Nigerian police force, to accommodate the growing number of the police officers deployed to the capital city.

The design of the housing scheme consists of about 600 units of single bedrooms and double bedroom apartments, which are all proto-type of detached bungalow units. The design was a compact style that comprises of bedroom, living area, combine toilet and kitchen in each detached unit.

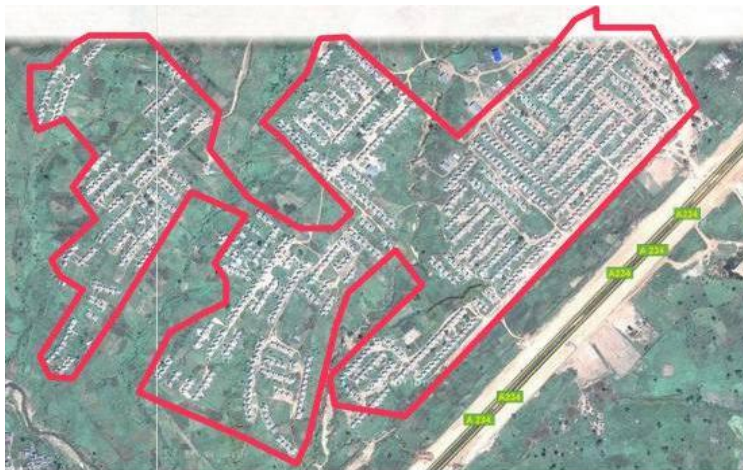


Figure 6. *Satellite image showing Jibi Low-cost Housing Scheme*



Figure 7. *Image showing a view of Jibi Low-cost Housing Scheme*

Jibi low-cost housing scheme has a several severe problems, no water supply is provided, no even consideration for security and privacy.

Table1. *Residents source of water to Jibi Low-cost Housing Scheme*

S/No	Level	Frequency	Percentage %
1.	Well	4	26.7
2.	Tanker service	11	73.3
3.	Borehole	0	0
4	Pipe borne water	0	0
	Total	15	100%

However, several other problems are discovered as follows:

- Houses are too hot in summer and usually too cool in hamattan
- Buildings have no cultural attachments to its users, both in planning, design and construction.

Finally, the research finding indicated that the residents' perception towards their dwellings was not positive

Table 2. *Perception of housing Quality by residents of Jibi Low-cost Housing Scheme*

S/No.	Level	Frequency	Percentage %
1.	Poor	12	80
2.	Fair	3	20
3.	Good	0	5.3
4.	Very good	0	0
	Total	15	100%

### 3. Results and Analysis

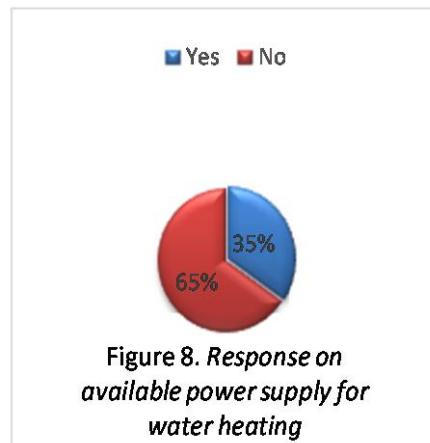
General findings were also made at various low cost houses around Abuja in consideration of selected factors to satisfy the reason for the installation of the Rainwater harvesting system and the Solar water heating for low cost housing schemes as follows;

Table 3. *Showing respondent of the study area.*

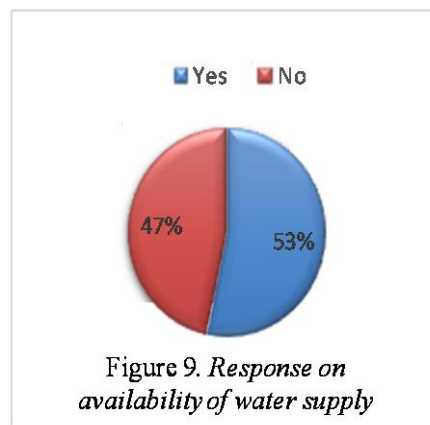
Residence	Respondent
Jibi low-cost housing	21
Nigerian Army Retired Officer's, Kurudu	25
Brick city, Kubwa, Abuja.	09

Table 4. *Response on availability of power supply for water heating*

	Yes	No
<b>Respondants</b>	19	36
<b>Percentage</b>	34.54	65.45

Table 5. *Response on availability of pipe-water supply*

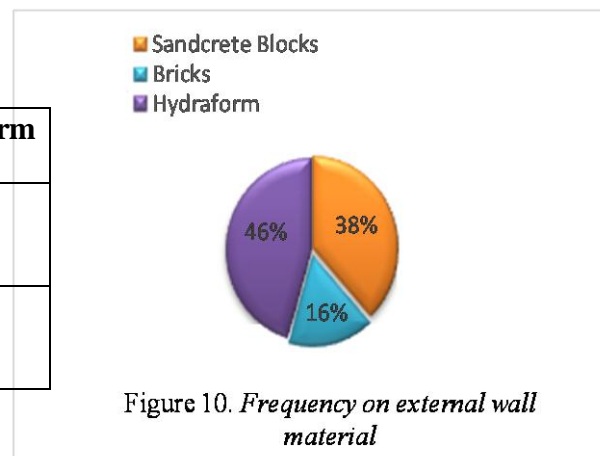
	Yes	No
<b>Respondants</b>	35	40
<b>Percentage</b>	46.67	53.33



borne

Table 6. *Response on the most common kind Of building material forexteriorwalls*

	Sandcrete	Bricks	Hydraform bricks
<b>Respondant</b>	21	9	25
<b>Percentage</b>	6.67	21.33	72.00



The survey was conducted in November, 2017, with a total of 55 questionnaires and interviews. Thus, more than 53 percent of the residents living in the low cost housing scheme do not benefit



from the amenity of pipe borne water, the few residents with constant water supply are sourced from privately sunk boreholes and often supply form water tanker services. Although some areas have all the necessary connections and services for the pipe borne water but it becomes available only from time to time and some area do not even have the necessary services for the supply but rather pay daily for water of which money is also needed daily for this supply. Water being a basic need for life should be prior, and should be made available through the easiest and cheapest medium to acquire for our day to day activities.

The jibilowcost housing, built for the low income earners experience a lot of challenges in their day to day living activities. Residents have to search for water in nearby well and streams or buy from truck pushers around, they have no pipe borne water, hence to ease the need for water as a basic need in life, the rainwater harvesting system sequel to a longer duration of the raining season in Abuja will go a long way in reducing daily cost of living, but a challenge is the high cost of installing the rainwater harvesting system. Government intervention can play a vital role in this aspect of providing funds for the low cost housing scheme, as well, various rainwater collection cisterns can be channeled to serve a single storage tank where it is further purified and in exchange it can serve numerous residents of the Jibi housing units thereby making the collective installation cost sustainable as no other cost will be required daily or monthly except on rare maintenance cases. Fire wood is hence needed as a source of energy for water heating which constitute to issues of global warming and also money is required for the daily purchase of the firewood. Since the issue of water cost would be solved by the rain water harvesting system, then the solar collectors can also give a solution for the water heating, no man made energy will be required, but the natural energy from the sun will be utilized for water heating, and depending on the volume of hot water needed for each housing unit, a considered size of the collector could also serve multiple houses so as to incur low installation cost, and a zero cost during the life cycle of the building after the installation. Another a major challenge is the comfort of the people staying in this houses, apart from the inadequate electricity, the wall materials used for this houses are not good enough interms of indoor thermal comforts and sequel to the high cost of electricity and even if they can afford to pay the electric bills, they do not have a constant electric supply to serve.

The Nigerian army retired officer's housing scheme at kurudu was started in consideration of the low military officer but was also allocated to interested civilians but still looks unfinished, although the hydraform been a very good walling materials, even better than the bricks was used, It still has the same issues of pipe borne water like the Jibilowcost housing wih an improvement in electricity, and can also be improved by the rainwater harvesting system and the solar water heating systems for a sustainable water heating

The red bricks city built by the Urban Shelters have far more ad vantages compared to other considerd low cost housing schemes. They were built in consideration to various economic hierarchies, but at a highier standard compare to 'Kurudu' and 'Jibi' lowcost housing. As the the name implies, Bricks wete utilized as a wall material which improves the indoor thermal comfort and improves the level of efficient energy use within the building units. Although there is a far better condition of electricity here, but the cost of these electricity needed for water heating is high and thus it is among the utmost issue that needs alternatives like the solar water heating, so that they could heat their water free of charge excluding installation and a very rear maintenance cost. The issue of in availability of pipe borne water still exist even with the improved living standard, and residents have to spend a lot of money to go into borehole drilling to have access to water or utilize water from tanker services which can be reduced and eased by the rainwater harvesting system.

Hence, sequel to longer days of wet season, the rainwater harvesting system will ease the availability of water. Furthermore the high cost of electricity required for water heating by electric water heater will be eased by the installation of the Solar water heaters which utilizes the

natural solar radiation for water heating as only initial cost will be required for the installation and no other cost required for daily heating except for maintenance purposes. Thus, the solar water heating will work together with the rainwater harvesting system for the water supply.

#### **4. Conclusion**

Rain water Harvesting System and solar water heating are measures of occupant's satisfaction. Like discussed earlier, it is deemed as important as the structural stability and safety of a building's design. These sustainable element must then be considered and implemented in the very early stages of design. According to analysis of the selected buildings, the integration of these elements have more positive effects than negative on the comfort levels of a building. For better effectiveness rates of these elements, they should be done in conjunction with proper building orientation, use of lightweight and sustainable building materials and they must be incorporated in the design as early as possible. This is a very important consideration when a designer wishes to produce a sustainable and reliable design.

However, as the priorities for each city in relation to sustainable development certainly vary, there are no simple, ready-made or uniform solutions to low-cost / affordable housing problems. However, for the urban poor in Abuja, the priority should be the attainment to basic socio-cultural, economic and political goals within the context of seeking to minimise demands for environmental resources. In line with this, it can be suggested that for quality and adequate housing to be affordable and sustainable, the government's housing commitments should include educating the professionals involved about sustainable development, reforming and devising sustainable policies and community involvement in housing provision.

Generally, the use of available local materials for building to develop any given culture should be encouraged by the concerned bodies within the building industry, sequel to the availability of these traditional building materials in Nigeria. The government should encourage the use of local materials in housing schemes like the 'Hydraform' for partitioning, in order to reduce the deficit on housing and also produce affordable housing. Thus, it is important for people living in hot weather like the north central Nigeria to implement the use of these local materials for their housing in order to improve their indoor thermal comfort and as well the sustainable elements for an efficient energy use.

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