



# The Prospective Impact of Renewable and Clean Energy Mix on Sustainable Energy Development in Nigeria

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## ABSTRACT

The study is a secondary research survey that examine the prospect of renewable and clean energy resources/mix on sustainable energy development in Nigeria. Qualitative/descriptive analysis approach were use in the analysis of the data. The study revealed Nigeria's different energy sources and their effectiveness and potentials in meeting Nigeria's energy needs. From the findings, Nigeria's renewable and clean energy resources; solar, wind, hydro, biomass, waste to energy (WTC), geothermal and nuclear option shows positive potential/prospect in meeting Nigeria's energy crisis combined. When harnessed by 2030 renewable energy projection will yield 190,000 MW of electricity, which will lead to sustainable energy development. United State based industry confirm that Nigeria solar energy industry is growing, As the FGN is working on installing over 5 million solar home systems to increase access to electricity in the rural communities. Also from the study FGN electricity roadmap (PPI), do not clearly indicate consideration for renewable energy.

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## 1.0 Introduction

Energy has proven to be the pillar and force for economic development and industrialization of all countries on the planet earth. Energy is the centre linking environmental, economic and sustainable development challenging the world now. Nigeria as a developing nation requires a strong and reliable energy services to contain her spontaneous population growth, which will then entail rapid development. Nigeria as a country that heavily depends on crude oil, this date back to 1970s to date, with crude oil forming 98% of export earnings, and 85% of government revenue. This dependence of Nigerian economy on oil has caused much concern. However, Nigerian first fossil energy discovered was coal, and crude oil was discovered 47 years after the discovery of coal [1]. Coal production started in 1916 with over 24500 tonnes for that year, but coal today contributes very little to Nigeria energy sector as compared with crude with over 70% and 25% for national gas. However, the Nigeria Railway consumed Nigeria coal as of then locally [1].

Nigeria is a nation blessed with abundance of energy resources/potentials in the form of solid, liquid and gas. Nevertheless, Nigeria has not found a way to turn her God given resources into prosperity. Nigeria as a nation continues to struggle from massive unemployment for her teeming population, massive underdevelopment across all geo-political zones, massive corruption, insecurity, not to talk of 60 years of electricity

undersupply. Nigeria with surplus of oil and gas resources at her doorstep is still suffering from energy poverty as well as fuel scarcity with her population spontaneously growing at an alarming rate. Energy and electrification, known to be the pillars of industrialization, are yet to be stabilized in a country with numerous potentials for development. Over the years, many foreign investors have abandoned the country due to power challenges [2]. This situation leaves organized labour with no option but self-generation, which results to overhead cost [2]. Aliyu *et al.* [3] reported that Nigeria is a country where less than 40% of her citizens and residents are linked to the nation's electricity grid infrastructure, is a thing to worry about. Report on National Geographic channel on 6 September 2020, revealed that "the electricity consumed by one American is equal to the same consumed by sixty-one Nigerian put together." Also according to World Bank, reported on Liberty TV News Channel on 24 April 2021, 6:30 AM Nigeria has the largest global number of people without access to electricity. World Bank chief economics Ayhan Kose warn Nigeria and the world at large that increase in electricity tariff inflation as supply constraints persist, other news outlet like Kaduna State Media Corporation (KSMC) and TVC News reported the same on 21 October 2021. In Nigeria, more than 50 million tons of wood are consumed yearly, at a rate that surpasses the replenishment rate of afforestation programs [1]. This also is another challenge due to inadequate energy sources across the country, especially among the rural community. The key questions

to address are: Why is sustainability so important? What mix of renewable and clean energy sources best addresses Nigeria's energy need?

### 1.1 Federal government electrification roadmap

As Nigeria's energy crisis continues to worsen, the federal government unveiled a roadmap strategy that was meant to not only solve the perennial problems, but also increase capacity for future energy needs in Nigeria. This led FGN to collaborate with German manufacturing giant Siemens. The roadmap initiative for Nigeria electrification between Siemens AG and Nigeria, represented by Bureau of Public Enterprise (BPE). The Nigeria Electrification Roadmap is structured into three phases. The first phase will focus on implementing projects that would greatly improve the power supply as soon as possible. Objectives of the agreement include the following: (1) To deliver an additional 2gigawatt (2GW) to grid (2) To significantly reduce aggregate technical and commercial losses (AT&C losses) and (3) To achieve improved grid stability and reliability. The second phase will target bringing the systems operational capacity to about 11GW, while the Third phase will involve increasing the system's capacity to 25GW with in the medium to long planning period, with appropriate upgrades and expansions in generating, transmission and distribution [4]. Nigerian current power capacity is 12,522 MW that is Nigeria installed capacity. Gas generation capacity is 10, 142 MW, while hydro generation capacity is 2,380 MW, according to USAID update 2020. However, Nigeria energy utility can only hold around 4,000 MW, which is considered inadequate/unsatisfactory, with population of over 200 million people. On TVC News Channel Program, Journalist Hangout on 30 October 2020; 5:30PM it was announced that Nigeria record her highest Power Transmission of 5,459MW; other news outlet as NTA recorded the same. The presidential power initiative (PPI) between Nigeria and Siemens AG do not clearly indicate any consideration for clean and renewable energy sources.

### 1.2 Nigeria's legacy energy infrastructure and management

Nigerian legacy energy infrastructure and management has passed from stage to stage to date from Nigeria Electricity Supply Company (NESCO) [5]. In 1929, to Electricity Corporation of Nigeria, in 1951 and in 1972 ECN was merged with NDA to form the National Electric Power Authority (NEPA), and NEPA as a result of the separation and electricity sector amendment was converted to power holding company of Nigeria (PHCN) in 2005. However, achieving the desired power supply was not realized with PHCN. Thus, another unbundling process was embarked upon through the signing into law on March 2005 of Power Sector Reform Bill that aimed at private sector participation in Nigeria electricity, generating, transmission and distribution. See Table 2 for installed capacity of generating companies (gen-cos). Six

generation/production companies were separated under the Obasanjo regime; however, the privatization programme was halted under the Yar'adua administration. But, President Jonathan in 2010 came up with the presidential Action Committee on Power (PACP) passing NEPA's assets to PHCN and unbundling PHCN into: A transmission company (TCN), six generation/production companies (GenCos) and eleven electricity distribution companies (DisCos) [6].

**Table 1: Profile of Electricity Infrastructure in Nigeria**

| GENERATION                  | PRE 1999           | POST 1999        |
|-----------------------------|--------------------|------------------|
| Thermal                     | 4058MW             | 5010MW           |
| Hydro                       | 1990MW             | 1900MW           |
| Installed Capacity          | 5996MW             | 6910MW           |
| Available Capacity          | 1500MW             | 4451MW           |
| <b>TRANSMISSION</b>         |                    |                  |
| 330KVA LINE                 | 4800KM             | 4889.2KM         |
| 132KVA LINE                 | 6100KM             | 6264.06KM        |
| <b>TRANSFORMER CAPACITY</b> |                    |                  |
| 330/132KV                   | 5618MVA            | 6098MVA          |
| 132/33KV                    | 6230MVA            | 7805MVA          |
| <b>DISTRIBUTION</b>         |                    |                  |
| 33KV LINES                  | 37,173KM           | 48,409.62KM      |
| 11KV LINES                  | 29,055KM           | 32,581.49KM      |
| 415KV LINES                 | 70,799KM           | 126,032.79KM     |
| <b>TRANSFORMER CAPACITY</b> | <b>8,324.56MVA</b> | <b>12,219MVA</b> |

Source: Oluseyi et al. [7]

**Table 2: Names and Installed Capacities of Gen-Cos**

| S/N | Generation Company              | Plant type | Capacity (MW) |
|-----|---------------------------------|------------|---------------|
| 1   | Afam Power Plc 1-V              | Thermal    | 987.2         |
| 2   | Egbin Power Plc                 | Thermal    | 1320          |
| 3   | Kainji/Jebba Hydro Electric Plc | Hydro      | 1330          |
| 4   | Sapele Power Plc                | Thermal    | 1020          |
| 5   | Shiroro Hydro Electric Plc      | Hydro      | 600           |
| 6   | Ugheli Power Plc                | Thermal    | 924           |

Source: Nigerian Electricity Regulatory Commission

**Table 3: Key Information of the 11 Discos in Nigeria**

| S/N | DISCOS                             | Percentages Load Allocation |
|-----|------------------------------------|-----------------------------|
| 1.  | Abuja Distribution Company         | 11.50%                      |
| 2.  | Benin Distribution Company         | 9%                          |
| 3.  | Eko Distribution Company           | 11%                         |
| 4.  | Enugu Distribution Company         | 9%                          |
| 5.  | Ibadan Distribution Company        | 13%                         |
| 6.  | Ikeja Distribution Company         | 15%                         |
| 7.  | Jos Distribution Company           | 5.50%                       |
| 8.  | Kaduna Distribution Company        | 8%                          |
| 9.  | Kano Distribution Company          | 8%                          |
| 10. | Port Harcourt Distribution Company | 6.50%                       |
| 11. | Yola Distribution Company          | 11.50%                      |

**Source:** Monthly Energy Balance Sheet, October 2013, Transmission Company of Nigeria (TCN)

### 1.3 Nigeria's main energy challenges

Commercial electricity power in Nigeria is produced by aged legacy electric infrastructures that date back to almost 60 years'. With supply not enough for almost 70% of the population. Electricity is the pillar and backbone of industrialization and economic prosperity of any nation [8]. Nigeria being one of the populated countries in ECOWAS, by estimation only around 40% of Nigerians are linked to the national electricity grid [3]. Nigeria is one of the leaders in primary energy production in the world yet Nigeria cannot meet the energy needs of her citizens and foreigners as well as private sector operating in the country, necessary for sustainable development [3]. Nigeria has the capacity to generate at least 12,000MW to stabilize her economic growth, but at the moment Nigeria can only transmit and distribute around 5000MW [9]. The vice President Professor Osinbajo's state, the Nigerian electric power supply industry is in a big mess of reliability and maintainability of its existing infrastructure which today still leads to the Nigerian populace experiencing unaccountable erratic problems of electric power supply. It is not possible to quickly forget the power crisis that hit the Nigerian state for about two weeks during the month of May 2015. This unfortunate reality grounded most business and the ones that were not grounded had to use electricity at very high cost. The reason at that time according to the National Electricity Regulation Commission (NERC), Chairman, Sam Amadi was that around 18 out of 23 electricity generating plants in Nigeria were unable to generate electricity as a result of insufficient of gas supply to the energy plants and one of the hydro plants have issue with volume of water leading to loss of around 2000 MW [10].

Therefore, by careful deduction, amidst the many causes of unavailability of electricity as examined here one can conclude the base root of Nigeria's unreliable power supply. One is the dearth of utilization of the abundant renewable energy sources from which electricity can be smartly generated into the Nigerian national electric grid.

Secondly is the major challenge of intermittent unavailability of fossil fuel energy sources used in Nigerian power plants which proportionally leads to regular blackout scenarios in many areas in Nigeria. Therefore, in reliability forms, Nigeria's power system is old and inadequate for the entire country. Coupled with the partial privatization from NEPA to PHCN and now GenCos-TCN-Disco's but yet we are still in alter energy scarcity, which now lead to the federal government engagement with Siemen AG for Nigeria Electrification Roadmap, by the present Administration.

### 1.4 The concept of sustainability

The concept of sustainability and its history is related to the well-being of mankind, society, sufficiency of natural resources, and preservation of ecosystems. The concept of sustainability results from the scarcity of resources of, there long term and natural disaster spark the discussion and research and development concerning sustainability of human society, agricultural land, wildlife, fish production, energy [11]. Sustainability development is the vision for the future. Natural calamities and natural disasters are intricately linked with and environmental sustainability. Economic viability is linked by an umbilical cord with energy and environmental sustainability. Self-reliance is the ultimate keyword in the future vision of a country's progress. Man's scientific vision and scientific urge will only be enhanced if there is concerted effort for ground work towards sustainable development. Government and civil society should be more inclined towards regulations and restrictions rather than policy implementation. Developing as well as developed world will all strive towards ushering in a new era of sustainable development [12].

### 2.0 Materials and Methods

The study is a survey study of the prospect of renewable and clean energy mix on the sustainable energy development in Nigeria. It looks into the different potentials of the different energy resources in Nigeria and how it could be harnessed.

#### 2.1 Source and method of data collection

The study is a secondary data survey analysis were relevant literatures/journals, libraries, Television news channel, newspaper, thesis, and online resources on the different forms of renewable energy and clean energy source were consulted.

## 2.2 Method of data analysis

The method of data analysis is a qualitative/descriptive analysis approach on the prospect of the different renewable and clean energy potential available in Nigeria; were recorded, examine/review and reported.

## 2.3 Population and sample size

The study areas are the entire country Nigeria with a land area of about 923,769 km<sup>2</sup> (3556, 669sq.m) and population in estimate of over 200,000 million people, where more than 70% of its population are not connected to the national electricity grid.

## 3.0 Results and Discussion

After analysing, examine/review existing literature on the different renewable and clean energy sources in Nigeria, the different energy sources and their effectiveness in meeting Nigeria's energy needs are discussed as follows:

### 3.1 Solar energy sources

Solar energy is the energy from the sun. Solar energy is transferred from the sun to the earth by radiation and the amount of energy flux reaching the top of the planet earth's atmosphere is projects [2].

about 1366 watts/m.<sup>2</sup> Solar energy can be used for variety of things from generating electricity, drying, crop growth and generating hot water for man's use. Solar energy has been used for electricity generation since 1876 when William Grils Adam and his student Richard Evans discovered that solid material-selenium produced electricity when exposed to sunshine or light [2]. The potentials of solar energy in meeting Nigerian energy needs is very huge. Sunshine or solar energy is one of the best renewable sources, being the cleanest among the renewables, solar energy has low effects on the environment, and the resources is abundant everywhere. Solar energy has the potential to lower energy bills, it requires low maintenance and its engineering is constantly improving. According to U.S Department of energy, mankind needs 410 quintillion joules of energy annually, and the sun ray coming or shining on the earth in one hour if trapped generates 430 quintillion joules of energy per hour i.e. higher than that consumed by mankind in an entire year. It therefore means that in 24 hours' mankind waste about 10,320 quintillion joules of energy per day. Solar energy resource is available in all parts of the country with an average sunshine hour of 5.535 kwh/m<sup>2</sup>/day. The vast expanse of Sahel Savanna in Northern region Nigeria provides more than enough space for this kind of

driven from wind movement to produce mechanical energy, then electricity [2]. Windmill is use for the generation of wind energy, which is also a clean energy source that has zero emissions and therefore is eco-friendly. Wind energy can help Nigeria energy need in terms of reducing fossil energy dependence, renewable, i.e. No fuel price volatility, unlimited and energy where, has the ability to place wind mill wherever necessary [13]. In Sambo [14] wind energy potentials for a number of Nigeria cities shows that the annual wind speed ranges from 2.32 m/s for Port-Harcourt to a sum of 3.89 m/s for Sokoto. In addition, in Tunde *et al.* [2], the wide area covered by Sahel savanna in the Northern region of Nigeria gives more than enough land area for this type of project.

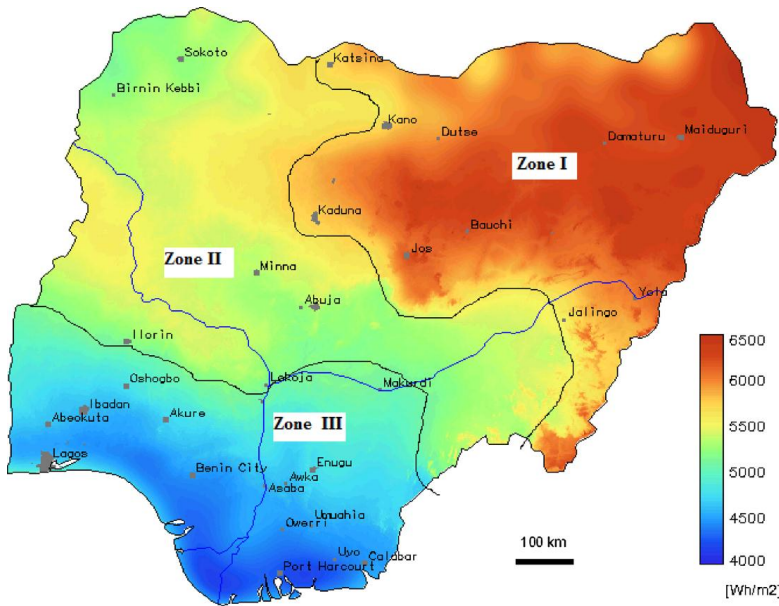
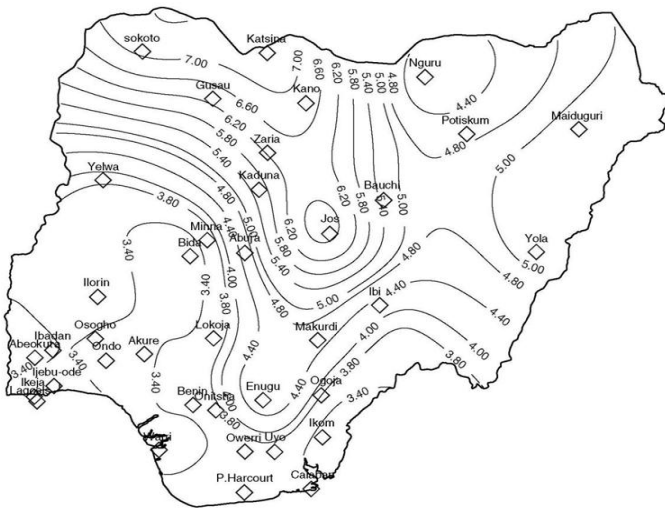


Figure 1: Solar Radiation map of Nigeria  
Source: Annual Performance of the Nigeria Economy (2010)

### 3.2 Wind energy sources

Wind is a renewable source of energy that can effectively meet Nigeria energy needs if properly utilized. Wind energy is



**Figure 2: Nigeria Wind Map in m/s Determined from 40 Year's Measurements at 10m Height, obtained from Nigeria Meteorological Department, Oshodi, Lagos State, Nigeria (NIMET) [2]**

### 3.3 Biomass sources of energy

Biomass refers to organic matter used as energy source, such as wood and wastes. Biomass of sources energy also originates from solar energy because it arises due to photosynthesis, Nigeria's form of biomass can be classified as wood biomass. Forage grasses and shrubs, residues and wastes (forestry, agricultural, municipal and individual) as well as aquatics biomass [15]. Biomass potential and effectiveness critical for Nigerians energy need, the country can utilize plant biomass as fuel for small-scale industries which could also be fermented by anaerobic bacteria to produce a cheap gas fuel (biogases or biofuel) [2]. In Sambo [16] reported by Tunde *et al.* [2] biomass potential, the renewable energy master plan (REMP) has projected biomass to contribute 50MW of electricity in the medium term set at year 2015 and 450MW by 2050.

### 3.4 Geothermal energy potential

In Shiva and Barat [13] geothermal energy is heat within the earth and only renewable energy created by nature. Geothermal energy is approximately 6400km below the planet earth's, where it temperature average 5000°C. The reservoirs can be tapped for a variety of uses, which include electricity, heating homes and its potential is 10km in the earth's crust which sum up to 50,000 times the fuel/energy of all oil and gas potentials of the world. Nigeria's geothermal potential is high but need technological manpower or know how for it utilization [2].

### 3.5 Hydro power

Hydro-electricity generation is among the oldest known renewable type of energy, known and used by almost all developed and developing Nations of the world. Hydroelectric power when properly harnessed can solve Nigerian energy need effectively. Nigeria has many hydroelectric potential across different geopolitical zones, hydro power has 90% conversion rate that is high efficiency. Hydro potential in Nigeria; Jabba 570MW, Kainji 760MW, Shiroro 600MW along with several dams across the country, given that 63% of Nigerian land is covered by water and 11m/s<sup>2</sup> potential of hydro power, Nigeria has a potential generating capacity of 6,396,396 MW of hydro electric energy [2].

### 3.6 Nuclear option

Justine and Anthony [17] stated Nigeria has uranium resources across six states in Nigeria. This mean Nigeria has nuclear potentials reveal that 1000MW of nuclear power plant is estimated to consume 162ton of uranium in a year using the once-through type of nuclear reactors which burn up only 0.7% uranium-235 and remove the remaining uranium-238 as waste [2]. Currently a more advanced breeder reactors, now in use, can convert uranium-238 into fissionable plutonium and requires about 3tons uranium per year to produce 1000MW of nuclear power if well optimized. With radioactive resource at Nigeria's disposal, Nigeria can generate 20,000MW nuclear power energy for sustainable industrial and economic growth.

### 3.7 Waste to energy (WTE)

Waste to energy is a renewable form of energy, with Nigeria accumulating huge amount of waste annually, without proper disposal plan. Waste to energy has massive potential in garbage, with the advancement of modern incinerator [18]. There is some prominent/rising technology called waste gasification, which could improve the environmental accomplishment of waste to energy. Gasification, where material is heated up in oxygen starved chamber, allows for control of emissions compared to combustion. This can be a good option for Nigeria energy mix, when properly worked on.

**Table 4: Target for Renewable Power Generation/Prospect (MW) in Nigeria**

| Resources            | Short term 2008 | Medium term 2015 | Long term 2030 |
|----------------------|-----------------|------------------|----------------|
| Hydro (large)        | 11,259          | 15,930           | 48,000         |
| Hydro (small)        | 3,500           | 7,430            | 11,900         |
| Solar PV             | 5               | 120              | 500            |
| Solar thermal        | -               | 1                | 5              |
| Biomass              | -               | 100              | 800            |
| Nuclear              | -               | 1,000            | 4,000          |
| Wind                 | 1               | 30               | 40             |
| All renewable        | 14,765          | 24,611           | 65,245         |
| All energy resources | 17,000          | 30,000           | 190,000        |

**Source: Energy commission of Nigeria. ECN annual report, Abuja (2011)**

In summary, United State based industry said Nigerian solar industry is growing (TVC News Channel 31<sup>st</sup> December, 2021; 1:53pm), other news outlet like KSMC Kaduna, NTA reported the same. Federal government plans for 45,101MW of electricity generating by 2030.

In addition, the federal government is working toward installing 5 million solar home systems to increase access to power supply in communities across the country (NTA, 2022).

Nigeria also unveiled plan for sustainable energy for all. That will increase power generation from 3000MW to 45,101MW by 2030. The federal government also plans to achieve this target gradually from the present 3000MW from fossil fuel to 18,200MW by 2030. Nigerian government, also disclosed the sustainable energy for all action document obtained by the Guardian on Tuesday, also expected renewable energy generation to reach 13,800MW. It said that by 2030, Nigeria would be producing 13000MW from gas, 3200MW from coal, 2000MW from nuclear energy, 5000MW from solar, 1000MW from solar thermal and 1100MW from biomass. This is key to increasing the global estimate of improvement in energy efficiency, ensuring global access to modern services and doubling the contribution of renewable in the global energy mix. Nigeria can tap into her nuclear potential, since Nigeria have uranium deposits in six states across the country.

Nigeria's expansion strategy in the energy sector includes the integration of energy resources that are non-fossil into the energy mix structure. Renewable energy is expected to contribute about 14, 23 and 36% for short, medium and long term of the overall energy and electricity supply in Nigeria by 2030. The targets for renewable energy production are presented, see table 3.0 above.

Furthermore, wind energy resources in the short term will require an increase of more than a hundred percent to produce

30MW in 2015 and 40MW in 2030. Wind power projects are beginning to be in existence and operational solar PV installations are on the increase and about 1mw total dispersed installations are going on country wide for low energy application such as water pumping, street lighting, vaccine, refrigerators and community lighting [19].

#### 4.0 Conclusion

Finally, the importance of renewable energy cannot be over emphasised. The study shows positive prospect of the use of renewable form of energy in meeting Nigeria energy needs for sustainable development. If Nigeria can harness it different energy potentials as examine it will go a long way in not just meeting Nigeria's energy needs, but also aid socio-economic development and sustainable development in the country. Solar energy is by far the most recognised renewable energy source since Nigeria is familiar with it technology. As united state based industry confirm that solar energy industry is growing in Nigeria. Wind, biomass, and geothermal, is another form of renewable energy that Nigerian government need to capitalized on as they show positive prospect in meeting Nigeria's energy need, but Nigeria need technology known how to utilize wind and geothermal energy prospect. Waste to energy is another form of energy Nigeria can harness since Nigeria releases large tons of waste annually, also nuclear option is another good energy potential, since it is a clean energy source. While hydro power has been the conventional energy source, with vast potential across the country, but still it potential is yet to be fully harnessed.

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