Geo-Environmental Strategies in the Energy Transition Era

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ABSTRACT

Geo-environmental strategies are imperative in this era of transition of energy system, from the present system to more conserved and effective system. Across the globe, environmental problems pose a challenge to actualizing efficient energy transition. Energy transition entails the shift from non-renewable fossil based systems of energy production and consumption to renewable energy sources. Energy transition cannot be actualized without effective implementation of certain geo-environmental strategies in order to mitigate its potential adverse effects and ensure effective harnessing of its profitable and advantageous potentials. The energy transition is a route toward ensuring the transformation of the energy sector the world over to zero carbon, in order to minimize energy related carbon(iv) oxide emission and other greenhouse gases (GHG) to ameliorate greenhouse effect. The energy transition could be achieved via thorough implementation of certain geo-environmental strategies. This paper discusses geo-environmental strategies that will ensure efficient energy transition from the present era of energy production and consumption system to a more de-carbonized energy production and consumption trend so as to mitigate climate change and other potential energy hazards in the environment, as well as harness its potential benefits. From the study, it is thus, crucial to explore and implore geo-environmental strategies to ameliorate energy hazardous effects to ensure efficient transition to a more de-carbonized energy production and consumption pattern so as to mitigate climate change and other potential energy hazards in the environment, as well as harness its potential benefits.

Keywords: Geo-environmental Strategies, Energy Transition, Renewable Energy, Green House Effects, Greenhouse Gases, Climate Change

INTRODUCTION

Geo-environmental strategies to ascertain effective energy era are essential toward minimal carbon emission. The transition entails a shift from fossil based to non –carbon emission. Geo-environmental problem is a serious matter on energy transition. Majorly, the safe disposal of carbon wastes from fossil energy resources in order to ensure public health, brings to fore the need to ensure energy transition to minimal or non-carbon energy to ensure clean environment. Geo-environmental strategies have enormous geological and geomorphological characteristics with palpable effects on socio-economic growth especially on energy sector.

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Human activities on the earth's surface are directly related to the physical environment, increasing the occurrence of geodynamic processes, such as landslides, siltation, flooding and others. (Correa, 2013) Thus, effective strategies in managing geo-environmental factors in this energy transition era is needful to actualize a successful transition from carbon energy resources to non-carbon or cleaner emission in order to ensure environmental safety and socio-economic growth .

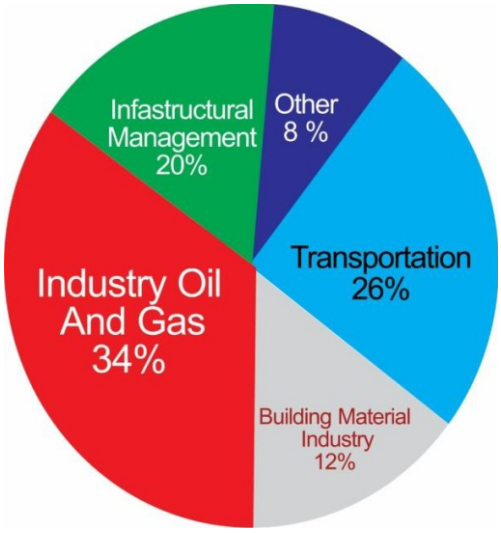
Most of our energy is non-renewable, such as petroleum, hydrocarbon, coal, natural gas, nuclear energy, especially in Nigeria and many other countries. They are formed over thousands of years from the remains of ancient sea plants and animals that lived millions of years in the past. To this effect, on public health and socio-economy, the need for transition from fossil fuels (non –renewable) energy source to non- fossil fuels (renewable energy) such as solar, biomass, hydropower, geothermal and wind energy in this era is recommended, especially owing to the dire need of demand for energy and the possibility of utilizing or harnessing other available sources. Renewable energy

sources such as solar and wind energy have the most capability to nip climate change in the bud. Owing to the environmental impact of the energy sector, there is need for transition from internal combustion automobiles, heat plumbs for infrastructures to most effective strategy or tool. Hence, a systematic energy policy to ensure minimal emission of greenhouse gases is needed.

This paper discusses geo-environmental strategies in the energy transition era from fossil fuel to non-fossil fuel sources.

Carbon Footprint reduction in oil and gas exploitation

Carbon reduction entails the ejection of emissions of $C0_2$ and other greenhouse gases made in order to ensure cleaner environment and more effective energy utilization. It ensures the absorption of carbon (di) oxide to bring carbon emissions to zero and prevent global warming. The oil and gas industry is a drastic imperative and sensitive sector managing $C0_2$ emission to ensure environmental safety and is crucial. Carbon emission emanates from engines, gas flaring, turbines, heaters, well analysis or drilling processes, and oil recovery (EOR) operation. Gas flaring engenders green house gas emissions in the energy sector, especially the upstream. Increase in coal use for power generation brings about $C0_2$ emissions and thus, a reduction in its usage is needed and transition to renewable energy sources is needed.



Pie Chart Showing $C0_2$ Consumption and Production in Nigeria (Odinkemere, J.C, Sept.,2022).

Substantial GHG emissions emanates from various activities such as fossil combustion, heat from sewage system and smoke from automobile exhaust pipe. Transportation automobiles emits about 4.6 meter tons of carbon (di) oxide per year, and thus, generates the largest share of C02 in the society. Energy source of transportation system emanates mainly from petroleum.

The impact of carbon footprints in oil and gas exploitation includes climate change, air pollution in urban areas, acid rain and coastal acidification, and the melting of glacier and polar ice. The petroleum sector plays a vital role in energy transition; thus, enabling sustainable energy needed to enhance growth in the energy sector producing fuels with de-carbonized emission is needful. Carbon (di) oxide emissions from oil and gas exploitation triggers air pollution and damages to agricultural products. Various ways to reduce C02 footprint emissions includes elimination of methane leaks, ensure carbon capture usage and storage (CCUS) development and deployment transition to improved energy source for efficient operations, tree planting or harnessing wind energy, and storage of biological carbon in forests, soils and, oceans. Transition from coal to gas for electricity yields enormous C02 footprint reduction in oil and gas exploitation. More so, conversion of gas to hydrogen, CCS, and enactment of greenhouse gas taxes could ensure carbon footprint reduction in oil and gas exploitation. C02 footprint reduction is vital for actualizing non-carbon emission in oil and gas exploitation, and meets the Paris agreement goal.

Renewable and Alternative Energy Opportunities In Nigeria

Renewable energy is energy that is derived from sources that are naturally renewed and replenished. In this era of energy transition, there are alternative sources of energy that are essential for utilization in Nigeria in order to enhance the energy sector and actualized cleaner environment and economic development. Alternative energy opportunities to non-renewable energy sources abound in Nigeria, such as solar, wind, hydro and geothermal. They seem to be more affordable, sustainable and efficient, and economically viable for economic activities such as transport system, power sector etc.

Renewable energy sources are most suitable in developing country like Nigeria, especially in rural areas for the generation and operation of certain system such as electricity, sewage, which are essential for human development; unlike non-renewable sources which are viable only in certain countries which are alternative energy sources. Renewable energy sources aids in ascertaining climate change mitigation, with lots of economic benefits. Most of renewable energy such as solar and wind can be converted to other energy such as heat for the operation of certain facilities such as sewage system, turbines and thus minimize the quest for primary energy requirements of non-renewable energy sources such as petroleum which is an alternative as is prevalent in Nigeria with potential environmental hazards and economic impact at utilization as they get depleted at consumption and are not replenished. Air pollution is minimized and reliance on imported fuels is curtailed, thereby ensuring economic enhancement when renewable energy is utilized. There is lower maintenance need for facilities in renewable energy. Above all, the ability to recycle renewable energy sources into other sources kind of energy makes it interesting and recommendable for utilization, unlike other

alternative opportunities such as petroleum. This means that renewable are increasingly displacing "dirty" fossil fuels in the power sector, offering the benefit of lower emissions of carbon and other types of pollution. But not all sources of energy marketed as "renewable" are beneficial to the environment. Biomass and large hydroelectric dams create difficult impact when considering the effect on wildlife, climate change, and other issues.

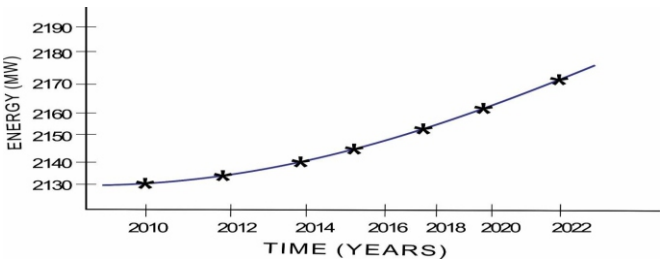


Figure 3: Graph of renewable energy opportunities demand in Nigeria till, 2022 (Odinkemere, J. C, Sept., 2022).

By 2022, demand for renewable energy alternative opportunities increased when reviewed from 2010. The National energy policy of Nigeria establishes guideline for the protection of the environment in the exploitation of Nigeria's fossil fuels. It also emphasizes the exploration of renewable and alternative energy sources, primarily solar, wind and, biomass.

In 2021, at the UN climate change conference, more commonly referred to as COP26, the Nigerian government announced an energy transition plan that seeks to meet its mid-century decarbonisation targets.

Geology and Geophysics Tools to Address Environmental Challenges

Environmental challenges are critical issues especially in energy sector, mainly during exploration and exploitation activities. Environmental geologist helps address these challenges by harnessing certain geologic and geophysical tools to mitigate and fix hazards to the ecosystem such as the coastal environment. Our wetlands, shorelines, streams and rivers are damaged during geologic processes; but environmental geologist help creates new wetlands, streams and river channels to replace those that were damaged during geological and geophysical activities. Wildlife and other geological species are endangered during exploitation activities which engenders certain environmental hazards such as oil spill on the coastal environment.

Substantial environmental issues faced by energy exploration, production and consumption industry are shown at various levels in the society. Environmental challenges such as ground water, soil, and air pollution, biodiversity and ecological hazards, oil spill which occasions aquatic damage are addressed via various geologic and geophysical tools and techniques.

Geologic and geophysical tools that could be harnessed to address environmental challenges are discussed bellowed.

Geologic tools:

· GIS: Global information system, makes it easy to assess the environment utilizing satellite image; which helps to check the natural resources such as groundwater, reservoir and oil wells and habitat of diverse species. An organization can monitor the distribution of different species and use this information to allocate funds for species, information garnered from GIS tools could aid in curbing oil spill and certain environmental challenges to ensure cleaner and safer environment. Furthermore, GIS enables advanced mapping and spatial analytics and enhances operational efficiency via rich location intelligence for oil and gas industry. GIS can also be applied in ameliorating climate change, population growth and habitat damage matters in the society. Issues such as flood, earthquake, erosion etc; can be controlled via the utilization of GIS tool.

· Remote sensing: helps in the collection of data on potential environmental hazards that could emanate during exploration and exploitation activities especial on ecosystem. Application of remote sensing in hydrological modeling, watershed mapping, energy and water flux estimation, fractional vegetation cover, impervious surface, area mapping, urban modeling and drought predictions based on soil water index derived from remotely sensed data is reported. Hence, help in addressing environmental challenges.

Geophysical Tools:

· Seismic refraction/reflection: mineral exploration has impact on the source area. They can be utilized to curtail effects on the environment making it safer, especially, on the application of geophones, dynamite, effective exploration activities with cleaner environment with seismic tools. Underground impact of seismic tools on wells, reservoirs, and water bodies are affected and curtailed by utilizing seismic methods. The seismic refraction method is utilized such that the seismograph data obtained help to determine precise depth to weathered basement and overburden thickness such that the different lithologies within the subsurface can easily be predicted (Tear pock and Bishkke, 1991).

Magnetic, electrical resistivity, ground penetration radar, and gravity techniques: These helps to address environmental challenges emanating from subsurface exploration and production activities. Application of these geology and geophysical tools/techniques could aid in addressing environmental challenges. It is used to characterize the subsurface geologic conditions and geologic structure in order to curb potential environmental

hazard such as tsunami wave that may emanate from the exploration activities within the coastline; and subsidence, ground water and air pollutions, stratigraphic changes occasioned by the use of seismic tools such as geophones and hydrophone in onshore and offshore environment.

GHG Emission as a Yardstick For Future Exploration Projects

Greenhouse gas is any gas that has the property of absorbing infra-red radiation (net heat energy) emitted from the earth's crust engendering greenhouse effect. They include C02, methane, and water vapor. GHG has palpable impact on exploration activity. Much emission is made into the atmosphere during exploration projects with impact on environmental safety and public health. GHG such as N02, C02, CH4 and some synthetic chemicals are trapped in beneath earth's crust during exploration project affecting the radioactive equilibrium of the earth.

Exploration activities such as combustion of fossil fuel generate lots of GHG into the environment. The oil and natural gas sector, according to survey is the highest contributor of GHG such as C02, CH4, and N02, into the environment. Exploration activities such as drilling and seismic investigations for fossil energy emit enormous GHG of during projects. GHG has lots of environmental health effects. They cause climate change and air pollution. They engender the flooding of coastal cities, desertification of fertile areas after executing exploration projects.

Controlling measures should be taken to ameliorate GHG effects during exploitation activities in order to ensure environmental safety and public health. They include enacting and ensuring exploration policy for safer exploration in the future; acquiring of carbon offsets, green indicators for effective education on GHG effects in the society ; and utilization of minimal or non-carbon drilling facilities and other GHG emitting materials during exploration projects.

Nevertheless, GHG has some positive impact on exploration activities that will enhance exploration projects in the future. They include, maintenance of earth's temperature at a level required for effective drilling activities supporting drilling mud efficiency, and the recycling of certain GHG such as CH4, N02, trapped in the atmosphere to energy needed for powering exploration machineries/equipment such a s drilling machines for oil and gas well; hence ensure effective exploration activities in the nearest future.

HSSE Risk Management (EIA) and waste management

HSSE risk management is a detailed method of controlling public health safety risks engendered by hazards in the workplace. Risks entail the tendency of hazard occurrence in the environment during and after exploration and production activities, and also during consumption by consumers.

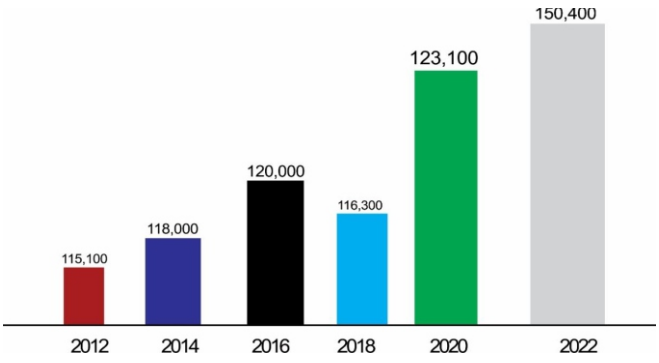


Figure 4: Nigeria $C0_2$ emissions – data chart till 2022 (Odinkemere J.C, 2022, sept.,2022).

Diagrammatic Representation of risk management / framework / guideline for HSSE risk management

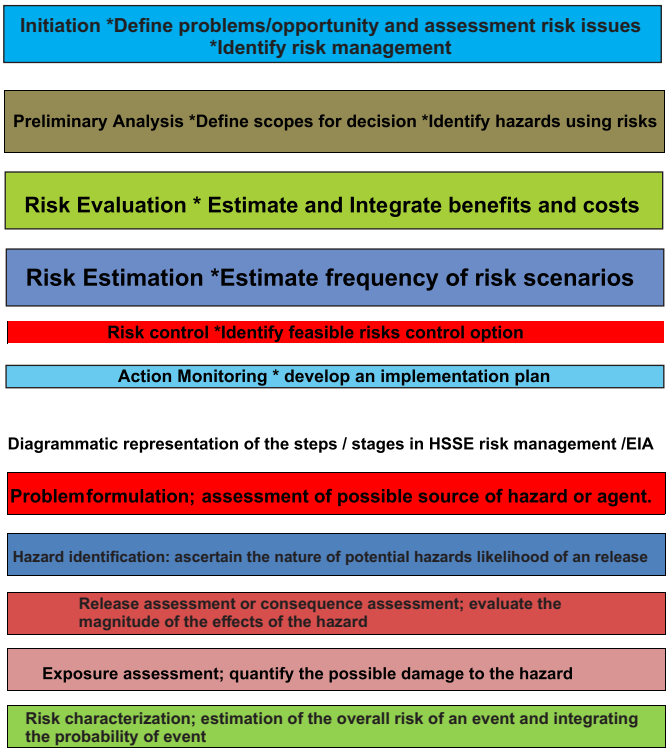


Figure 5: Steps/ Stages in environmental impact assessment/ Risk management (Modified by Odinkemere, J.C; after Dr. A.I Okpara, Sept., 2022).

EIA ensures the identification of the significant impacts and mitigation measures, to avoid irreversible damage to the environment and to ensure sustainable use of natural resources. (Badar, 2009) EIA is internationally recognized as standard environmental management tool for decision making process (Naser, 2012).

Waste management

Wastes are emitted at various stages of the oil and gas exploration and production cycle from exploration to consumption. They have the potential to harm the

environment and impact workers health, if not properly contained, managed, or disposed. In oil and gas sector, waste include oil that has been contaminated via leaking container s sediments that are found at the bottom of oil tanks and oil that spill across coastal and onshore region.

Types of waste management

· **Recycling:** This entails reproduction of various products from waste product. Waste oil can be re-refined into lubricants, fuel oil and utilized as raw materials for refining and petrochemicals industries. More so, used oil filters contain reusable scrap metal, which steel producers can use to as scrap feed. Waste oil can be recycled more to finished products such as engine oil, transmission fluid, and brake fluid, etc.

· **Incineration:** is the process of burning hazardous materials at temperatures high enough to destroy contaminants. It usually destroys organic constituents in wastes materials. Though it has negative effects due to increasing quantities of wastes sent to incineration, incinerators will emit more toxins and pollutants that harm local air quality and cause flue gas and heat which proceeds from ash formed by inorganic constituents of the waste and may take the form of a solid lumps or particulate carried by the flue gas.

· **Landfill:** In landfill, a huge pit is made in open low lying areas, usually way from the places where people reside. The waste is collected in huge trucks and dumped into the pit., once the pits are filled, they are covered with soil and left for decomposition. Because most of these waste materials are non-biodegradable, they heap in the landfills where they stay for years. Examples of such wastes include wood, paper, plastic, broken furniture, glass, market waste. They are usually municipal solid wastes (MSW) that emanates from municipal regions of the society.

· **Biologies:** here wastes are reduced into fractions that will undergo further treatment such as composting anaerobic digestion, combustion, where they are consumed by living organism and eventually returned them to the environment usually in a different form for reuse. The organism portion of reuse is allowed to decompose under carefully managed conditions. Microbes metabolize the organic waste material and reduce its volume by as much as 50 percent. UNC-CH biological waste disposal policy stipulates proper procedures for the collection, decontamination, and disposal of laboratory generated biohazard. Other methods include animal feed, reprocessing.

The Environment and Regulatory Frame Work

The environmental regulatory frame work index evaluates a nation's environmental regulatory legislation and their involvement with major multilateral environmental agreements. It is the basis to any investigation of energy related environmental impact of infrastructures. It provides a constituent and comprehensive system for describing physical interaction arising throughout their life cycle of buildings. They exist on national and international levels.

There are components of environmental regulatory frame work: they include regulator, target, command, and results, which affects the benefits and flexibility that regulations provides. Environmental agencies are commissions, bodies, ministries, or organization established by law of oversight, administration and protection of the environment and its resources against misuse and degradation from human resources.

In Nigeria, environmental protection agency (EPA) is a federal government agency, created by Nixon Administration, to protect human health and the environment. The EPA creates and enforces environmental laws, inspect the environment, and provide technical support to minimize threat and support recovery planning. These laws and regulations help guide against unwarranted environmental pollution occasioned by energy exploration, production and consumption. There are so many environmental frame work in our nation Nigeria, due to oil exploration, exploitation, especially in the Niger Delta region; as a result of various environmental and regulatory agencies were formed from the ministry of environment to monitor the environmental impact of industrial activities in the nation , especially in the energy sector. Such agencies include NESREA (national environmental standard and regulations enforcement agency), national Park service (NPS), Forest research institute of Nigeria (FRIN), National agency for great green wall (NAGGW), National bio-safety management agency(NBMA), National oil spill detection and response agency (NOSDRA) etc.; formed to ensure compliance with all existing environmental legislation and detection of oil spill in the oil producing areas in Nigeria, and also safeguard human health and the environment from potential adverse effects of modern biotechnology, address land degradation and desertification and support communities to adapt to climate change etc, with their impact, effective energy transition to cleaner and safer environment can actualized.

Host Community and Local Content: Synergy and Challenges

The Nigeria oil and gas development Law 2010 defines local content as the quantum of com posite value added to or created in Nigeria through utilization of Nigerian resources services in the petroleum industry resulting in the development of the indigenous capability without compromising quality, health, safety.

Local content is the development of local skills, oil and gas

technology transfer, and use of local manpower and local manufacturing. For a more practical definition, one could say that local content is building a work force that is skilled and building a competitive supplier base (oil and Gas, 2010). It is the value that an extraction project brings to the local regional or national; economy beyond the resources revenues.

A host community in the context refers to the community and the local, regional and national governmental, social and economic structures with which natural resources are located, explored, and possibly exploited and produce. Synergy needs be built between host community and oil and gas industries on beneficial and impactful projects on the communities and hence, foster peace and understanding between the duos. The industries can assist in the funding of certain local community support projects; organize skill acquisition projects, employment of more personnel into the system from the host communities and also construction of infrastructural projects such as road, bridges, sewage and educational facilities that foster synergy between the host and energy sector in the area. Local content agencies such as the Nigerian Content Development and monitoring board (NCDMB), can liaise with hoist communities for beneficial and impactful projects in the operation areas. Furthermore, Nigeria oil and gas industry development (NOGICD) Act, recognizes the place of host communities and thus, issue the community content guideline to protect rights and privileges in oil and gas operations. More so, the NCDMB created the community contractors finance scheme as part of the Nigerian content intervention fund (NCIF), where qualified firm can access fund for funding valid project in the energy sector in the host communities.

The Nigerian oil and gas industry content development (Local content Act), 2010 was enacted to promote the indigenous participation in the Nigeria's oil and gas industry for the purpose of improving the economic and social wellbeing of those engaged in operating in the oil and gas industry. The Act provides for the development of Nigerian content in the oil and gas industry, Nigerian content plan, supervision, co-ordination, monitoring and implementation of the Nigerian content. (Olusola John Jegede). This law poses a challenge to most firms that cannot meet the standard and operational requirement of the Act. The petroleum industry Act 2021 (the Act) introduces the petroleum Host community development (PHCD) under section 234 of the Act. The Host Community Development Trust was introduced by the Act to aid in the development of the economic and social infrastructures of communities in the petroleum producing areas. (Olusola John Jegede, Winifred Idiaru). Indifference on the part of host community to corporate with energy industry in their area for synergy for effective beneficial projects, and provision of peaceful co-existence between them and industry also constitute a challenge.

CONCLUSION

Energy transition from present energy source to the era of cleaner and safer energy source is achievable via ensuring effective carbon footprint reduction during exploitation of energy resources; harnessing alternative energy opportunities to non-renewable energy sources such as petroleum as prevalent in many countries such as Nigeria. Greenhouse gas emissions during exploration projects in the future are necessary to be curbed in order to nip greenhouse effects such as climate change, acid rain, etc in the bud.

Environmental and regulatory frame work, HSSE risk management, and proper waste management via the implementation of EIA before and after exploration and production processes is necessary in order to actualize energy transition to safer source.

Recommendation

· Energy transition from the present energy source to the era of cleaner and safer source via harnessing and implementing effective geo-environmental strategies and tools could be actualized.

· Carbon footprint reduction in oil and gas exploitation via utilization of carbon capture usage and storage (CCUS) facilities for the conversion of gas to hydrogen which is safer to the environment; mitigation of methane vents and flaring, harnessing of wind and solar energy and, enactment of green house gas taxes is needful to actualize effective energy transition era to safer and cleaner source.

· Exploring and harnessing renewable energy sources such as solar and wind energy and their conversion to other energy such as heat for the operation of certain facilities such as turbines and sewage facility is recommended to alternative energy opportunities such as petroleum which could not replenish.

· Geology and geophysics tools such as GIS, remote sensing, etc could be harnessed in addressing environmental challenges, especially, oil spills in onshore and offshore environment during exploration and production processes.

· Proper synergy between host community and energy industry in producing areas is recommended for proper management of emissions from industrial processes and activities in their area and ensure economic growth, environmental safety and public health in their areas.

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