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PSECC LTD

GEOTHERMAL PLANTS PROPOSAL CONCEPT

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Project No. PSECC001

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Baseload Transitional Clean Energy

Net ZERO

PSECC Ltd

Portsmouth Sustainable Energy & Climate Change Centre

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NATIONAL STRATEGY

National Electrification Strategy

COP28 indicated the importance of Adaption and to “Transition” into a Net Zero economy. Geothermal Plants - National Electrification Strategy: achieve universal electricity service to all households and businesses by 2022 at acceptable quality of service levels. Produce 100 000 barrels of oil per day from 2022 and develop 2,275 MW of geothermal capacity by 2030.

The use of geothermal energy, or heat contained in rocks and fluids beneath the Earth’s surface, is expanding around the globe. Geothermal energy can generate a continuous supply of heat to power homes and office buildings. It can produce just one-sixth of the CO_2 emissions produced in a natural gas plant. Today, geothermal energy in Kenya has emerged as a sustainable power source and contributed to poverty-reduction throughout East Africa.

Kenya has set out ambitious targets for geothermal energy, aims to expand its geothermal power production capacity to 5,000 MW by 2030 and we support, with a medium- term target of installing 1,887 MW by 2017. Although there is significant political will and ambition, reaching these ambitious goals is a major challenge.

The Menengai Geothermal Project, in Nakuru County, has an estimated potential of 1,600 MW. The project will be developed in five (5) phases with the long-term goal of developing 465 MW of geothermal steam equivalent.

The Baringo-Silali Geothermal Project has an estimated geothermal potential of 3,000MW. The Company plans to develop 300MW in the first phase of the project, that is, Paka – 100MW, Korosi – 100MW, Silali – 100MW.

President Ruto's commitment

President William Ruto in November 9, 2022 had arrived back from Sharm El-Sheikh, Egypt where he attended the 2022 United Nations Climate Change Conference (COP27). The President called on developed nations to invest in Africa to unlock its clean energy production potential citing wind power, geothermal electricity, and solar energy.

The President signed a framework agreement for collaboration on the development of sustainable green industries in Kenya with an investor to produce 30 GW of green hydrogen in Kenya. There exists opportunities in Kenya to produce 20 GW of wind-power, 10 GW of geothermal electricity and being at the equator, considerable amounts of solar energy.

Fig 1. PSECC Targeted projects

PSECC Ltd - Phase One Railway & Economic Zones - Energy Installed & Cost Recommendations to meet Kenya Government, LCDA targets, NDC's and IPCC emission reduction.

		MW (2024 – 2028)		Cost	MW (2028 – 2035)		Cost
• expansion in geothermal	-	1,887	MW	US$ 2,830 m	3,113	MW	US$ 4,669 m
• solar PV	-	500	MW	US$ 500 m	500	MW	US$ 500 m
• solar farms	-	2,000	MW	US$ 1,770 m	1,000	MW	US$ 885 m
• solar PV Manufacturing plant	-	25	MW	US$ 10 m	50	MW	US$ 20 m
• waste plants	-	180	MW	US$ 900 m	180	MW	US$ 900 m
• wind farms	-	150	MW	US$ 328 m	350	MW	US$ 766 m
• green hydrogen	-	1,100	MW	US$ 1,432 m	1,100	MW	US$ 1,432 m
• dams – hydroelectricity	-	796	MW	US$ 796 m	500	MW	US$ 500 m
• climate smart agriculture Bio-Fuels	-	191	M Ltrs	US$ 190 m	150	M Ltrs	US$ 190 m
• Nuclear	-	-	-	- -	940	MW	US$ 4,800 m
• Clean Coal Technology	-	2,040	MW	US$ 2,107 m	-	-	- -
	Total	8,869	MW	US$ 10,863m	7,883	MW	US$ 14,662 m

<u>PSECC Ltd propose 5000MW of Geothermal plants</u>

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Leading the Way

Kenya is the leading producer of geothermal energy on the African continent and eighth in the world. The nation has helped set a valuable precedent for building green infrastructure and implementing sustainable poverty-reduction efforts. Additionally, Kenya will soon be in a position to offer other countries its geothermal equipment and expertise. KenGen intends to construct some of the first geothermal plants in neighboring countries such as Uganda and Ethiopia. Furthermore, the company has scheduled geoscientific investigations in Rwanda and the Comoros Islands. KenGen has partnered with the Kenyan government, Japan International Cooperation Agency (JICA), the World Bank and United Nations Development Programme to garner support for resource development.

Now more than ever, geothermal energy in Kenya is a promising alternative power source. Though not without its challenges, energy drawn from inside the earth promotes numerous financial and environmental advancements. In the end, geothermal energy can help Kenyans propel themselves and their neighbours down a sustainable path to economic stability.

The Prime Location

To access geothermal energy, production teams dig wells deep into reservoirs of steam and hot water. The method of access limits geothermal energy plants to locations along tectonic plates. For this reason, some have called geothermal energy “the most location-specific energy source” in the world. With an estimated geothermal potential of 10,000 megawatts, the Great Rift Valley in Kenya holds exceptional promise for clean-energy development. The Rift spans nearly 4,000 miles, extending north into Lebanon and south into Mozambique. Situated in the middle of the fault line, Kenya is in a position to harness vast stores of underground energy.

The first geothermal site opened here in 1984, in the region of Olkaria (about 150 miles from the nation’s capital, Nairobi). At the moment, Kenya is working to expand its 23 sites, only four of which contain deep wells. While geothermal power plants in Olkaria maintain a generation capacity of around 700 megawatts and can power nearby major cities, geologists hope to double their impact by 2025.

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On Track to a Sustainable Future

Geothermal energy in Kenya remains vital to ensuring a sustainable future nationwide. Unlike natural gas or even solar power, geothermal energy is safe from climatic hazards. In addition, it is available year-round and is relatively low-cost after drilling. Accounting for half the power in Kenya on some days, it has alleviated the national energy shortage. Moreover, it helps provide 75% of Kenyans with access to electricity. This is a significant increase from 56% in 2016.

Kenya Electricity Generating Company (KenGen) recognizes the need to implement geothermal energy in sustainability efforts. According to Cyrus Karingithi, Head of Resource Development at KenGen, “We are too dependent on hydropower and this poses a real problem with the repetition of droughts.” Two-thirds of the power in Kenya came from dams in 2010. With the rise of geothermal energy, innovative companies like KenGen have reduced that number to less than 50% and are aiming for 28% by 2024. To achieve their goal, geologists will continue to identify new drilling areas along the fault line.

Economic Growth

Harvesting geothermal energy in Kenya provides environmental solutions, and it also stimulates economic growth. As geothermal plants create jobs and power Kenyan businesses, these operations can wield a direct influence on the fight against poverty. For instance, Oserian is one of the leading flower exporters in Kenya. Oserian relies on geothermal energy to heat greenhouses and sell 380 million flower stems each year. In addition, the company can grow new rose varieties with a 24-hour heating supply. The same geothermal plant generates power for 300,000 other small or medium-sized businesses in the area. With a fast-growing economy, Kenya is already moving toward industrialization and modernization. The nation hopes to be an upper-middle-income country within the next decade. Officials remain optimistic that geothermal energy can power burgeoning industries throughout the country.

BENEFITS GEOTHERMAL

Developing further geothermal plants in Kenya, especially in the context of the Lamu Port-South Sudan-Ethiopia Transport (LAPSSET) Corridor, can bring about various energy, environmental, and climate change mitigation benefits.
In summary, further developing geothermal plants in the LAPSSET Corridor offers a suite of benefits, aligning with goals related to sustainable development, environmental conservation, and climate change mitigation.

Here are some key advantages:

Global Climate Leadership:

As a part of global efforts to combat climate change, the expansion of geothermal energy in the LAPSSET Corridor positions Kenya as a leader in sustainable and low-carbon energy solutions, contributing to the country's international climate commitments.

Climate Resilience:

Geothermal energy is not dependent on weather conditions, making it a climate-resilient energy source. It provides a stable and continuous power supply, even during adverse weather events that may affect other renewable sources.

Clean and Renewable Energy:

Geothermal energy is a clean and renewable source of power. Developing additional geothermal plants in the LAPSSET Corridor contributes to a diversified energy mix, reducing reliance on fossil fuels and enhancing the sustainability of the energy supply.

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Reduced Greenhouse Gas Emissions:

Geothermal power generation produces minimal greenhouse gas emissions compared to conventional fossil fuel-based power plants. By expanding geothermal capacity, the LAPSSET Corridor can significantly reduce carbon dioxide and other pollutant emissions, contributing to climate change mitigation.

Stable and Baseload Power Supply:

Geothermal energy provides a stable and consistent baseload power supply. Unlike some renewable sources, such as solar and wind, geothermal plants can operate continuously, providing a reliable source of electricity to meet the energy demands of the corridor.

Energy Security and Independence:

Geothermal resources are indigenous and not subject to international fuel price fluctuations. This enhances energy security and reduces dependence on imported fuels, contributing to greater energy independence for the LAPSSET Corridor.

Job Creation and Economic Development:

The development, construction, and operation of geothermal plants create employment opportunities. This can stimulate economic development in the regions along the corridor, fostering local skills and expertise in the geothermal energy sector.

Geothermal Heat Utilization:

In addition to electricity generation, geothermal resources can be used for direct applications such as district heating, industrial processes, and agricultural activities. This utilization of geothermal heat can further enhance energy efficiency and reduce reliance on other energy sources.

Reduction of Air Pollution:

Geothermal power plants produce minimal air pollutants compared to fossil fuel-based plants. The reduction in air pollution contributes to improved air quality, leading to health benefits for the communities in and around the LAPSSET Corridor.

Water Conservation:

Geothermal power plants generally have lower water consumption per unit of electricity generated compared to conventional thermal power plants. This is particularly important in regions where water scarcity is a concern.

ENERGY TRANSITION

GEOTHERMAL ENERGY IN KENYA

With an installed capacity of 863 MW, geothermal produced around 48% of all electricity supplied in Kenya in 2020/ 2021.

Within the Lapsset Corridor project we will enhance the capacity of Kenya with three more Geothermal Power plants utilising Kenyan companies. The cost of building a geothermal power plant depends on the size and location of the plant, as well as the type of technology used. The U.S. Department of Energy (DOE) estimates that a small geothermal power plant can cost between $0.5 million and $1 million per megawatt (MW), while larger plants can cost up to $2 million per MW.

CLIMATE CHANGE MITIGATION

Global Climate Leadership:

As a part of global efforts to combat climate change, the expansion of geothermal energy in the LAPSSET Corridor positions Kenya as a leader in sustainable and low-carbon energy solutions, contributing to the country's international climate commitments.

Climate Resilience:

Geothermal energy is not dependent on weather conditions, making it a climate-resilient energy source. It provides a stable and continuous power supply, even during adverse weather events that may affect other renewable sources.

The development of further geothermal plants within the LAPSSET Corridor can yield significant results in terms of climate change mitigation. Geothermal energy is considered a low-carbon and environmentally friendly energy source. The specific amount of carbon dioxide (CO_2) savings depends on several factors, including the capacity of the geothermal plants, their efficiency, and the carbon intensity of the energy sources being displaced.

Developing 5,000 MW of geothermal energy within the LAPSSET Corridor, with the assumptions mentioned, could potentially save approximately 15,768,000 tonnes of carbon dioxide annually. It's important to note that these calculations are estimates, and actual values may vary based on specific project details and local conditions.

ALIGNMENT WITH LAPSSET

The development of more geothermal plants in Kenya can align with the energy strategy of the Lamu Port-South Sudan-Ethiopia Transport (LAPSSET) Corridor in several ways. Here are key considerations for the alignment:

1. Diversification of Energy Sources: Integrating geothermal energy into the LAPSSET Corridor's energy strategy contributes to diversifying the energy mix. By relying on multiple sources, including geothermal power, the corridor can enhance energy security and resilience, reducing vulnerability to disruptions in any single energy supply.
2. Sustainability and Environmental Considerations: Geothermal energy is a clean and sustainable energy source with low greenhouse gas emissions. Its development aligns with environmental sustainability goals, contributing to the reduction of carbon footprint and air pollution. This is particularly relevant for a large-scale infrastructure project like LAPSSET, where sustainable practices are crucial.
3. Reliable Baseload Power: Geothermal power plants provide a stable and reliable baseload power supply. The continuous operation of geothermal facilities can complement intermittent renewable sources like solar and wind, ensuring a consistent and resilient energy supply for the LAPSSET Corridor.
4. Local Resource Utilization: Kenya has substantial geothermal resources, and the development of geothermal plants allows for the utilization of local resources. This contributes to regional economic development and reduces reliance on imported energy sources, aligning with the goal of maximizing the use of indigenous energy resources.

5. Economic Development and Job Creation: The development, construction, and operation of geothermal plants create job opportunities and stimulate economic growth. This aligns with broader development objectives, fostering local employment and supporting the socioeconomic development of communities along the LAPSSET Corridor.
6. Energy Independence: Geothermal energy, being a domestic resource, enhances energy independence. By incorporating geothermal power into the energy mix, the LAPSSET Corridor can reduce dependency on imported fuels and mitigate risks associated with fluctuations in global fuel prices.
7. Integration with Regional Power Grids: Geothermal power can be integrated into regional power grids, promoting connectivity and collaboration with neighbouring countries. This alignment supports the broader regional energy cooperation goals of the LAPSSET Corridor.
8. Climate Change Mitigation: Geothermal energy is a low-carbon technology, and its deployment contributes to climate change mitigation. Given the global emphasis on reducing greenhouse gas emissions, incorporating geothermal power aligns with international climate goals.
9. Long-Term Sustainability: Geothermal plants typically have long lifespans and low operating costs after initial investment. This aligns with the long-term sustainability objectives of the LAPSSET Corridor, providing a reliable and cost-effective energy source over the project's lifecycle.
10.

In summary, the development of more geothermal plants in Kenya aligns with the energy strategy of the LAPSSET Corridor by contributing to energy diversification, sustainability, economic development, and regional energy cooperation. It enhances the corridor's resilience, reduces environmental impact, and supports the achievement of long-term energy and development objectives.

TIMELINE

Following is the tentative timeline of the Geothermal programme, divided into 3 phases:

Phases	Name	Description	Time Frame
Phase 1:	Implementation / Feasibility	Strategic pathway	2024
Phase 2:	Five plants	1,887MW total	2024 to 2028
Phase 3:	Ten plants	3,113MW total	2028 to 2035

COST

The details of the indicative cost are provided below (dependent upon exact criteria):

Title	Cost (USD)	Installed Plant cost
Phase 1. Implementation / Feasibility Study / EIA etc (approximately)	$300,000	
Phase 2. Five plants	$2 million to $4 million per MW	$3.77 Billion to $7.74 Billion
Phase 3. Ten plants	of $2 million to $4 million per MW	$6.22 Billion to $12.44 Billion

Items	Cost
PSECC Ltd coordination	
Coordinator	To Be Determined
Project Manager	To Be Determined

The cost per megawatt (MW) to build geothermal plants can vary based on several factors, including project size, location, resource quality, technology advancements, and specific project requirements.

We can provide a general overview of costs per MW installed, based on historical data.

Historically the cost to build geothermal power plants has been in the range of $2 million to $4 million per MW for large-scale projects. It's important to note that costs can vary, and more recent data may reflect changes in technology, market conditions, and project-specific factors.

Here are some factors influencing the cost per MW for geothermal plants:

Resource Quality: The quality and temperature of the geothermal resource can impact the cost. Higher-temperature resources often require less drilling and can be more cost-effective.

Drilling Depth: The depth and complexity of drilling required to tap into the geothermal reservoir can significantly affect costs. Deeper and more complex drilling tends to increase project expenses.

Technology Advances: Advancements in geothermal technology can influence costs. Improved drilling techniques, more efficient turbines, and other technological innovations can impact project economics.

Economies of Scale: Larger projects may benefit from economies of scale, potentially reducing the cost per MW. However, large-scale projects may also face challenges related to grid integration and transmission.

Geographical Location: The location of the geothermal plant, including its proximity to existing infrastructure and the ease of transporting equipment, can impact costs.

Regulatory Environment: Regulatory requirements and permitting processes can affect project timelines and costs. Clear and streamlined regulatory frameworks may contribute to cost efficiency.

Financing Terms: The terms of project financing, including interest rates and access to international funding, can influence the overall cost of the project.

For the most accurate and up-to-date information on geothermal plant construction costs in Kenya, it is recommended to consult recent reports from relevant authorities, industry publications, or contact local energy authorities and project developers involved in geothermal projects in the region. Keep in mind that the cost landscape can change over time as technology evolves and market conditions shift.

REVENUE

PSECC Ltd calculations (to be confirmed once plant is operational and O&M considered) – indicative.

Items	Revenue (USD)
Yearly Energy Generation from 5,000MW plant (total) producing 39,420,000MWh – electricity sold at $0.05 KWh	$1.97 Billion
Government 35% share of revenue per year	$689 Million
Total Government revenue share over 20 years	$13.79 Billion

Loan repayments will then have to be made.

Full feasibility studies to determine exact amounts.

CARBON DIOXIDE SAVINGS

To estimate the potential CO_2 savings, we can use the following formula:

CO_2 Savings=Electricity Generated (in MWh)×Carbon Intensity (in kg CO_2/kWh)CO_2 Savings=Electricity

Generated (in MWh)×Carbon Intensity (in kg CO_2/kWh)

Now, let's make some assumptions for this calculation:

1. **Geothermal Capacity Factor**: Assume a conservative geothermal capacity factor of 90%. Geothermal plants typically have high-capacity factors due to their ability to operate continuously.

2. **Carbon Intensity**: Assume an average carbon intensity of 0.4 kg CO_2/kWh. This value is a general estimate and may vary based on the energy mix being displaced.

Using these assumptions, we can calculate the annual CO_2 savings for 5,000 MW of geothermal energy:

Electricity Generated=5,000 MW×0.90 capacity factor×8760 hours/year Electricity Generated=5,000MW×0.90capacity factor×8760hours/year

CO_2 Savings=Electricity Generated×0.4 kg CO_2/kWhCO_2 Savings=Electricity Generated×0.4kg CO_2/kWh

Now, let's perform the calculations:

Electricity Generated=5,000 MW×0.90×8760Electricity Generated=5,000MW×0.90×8760

Electricity Generated=39,420,000 MWh Electricity Generated=39,420,000MWh

CO_2 Savings=39,420,000 MWh×0.4 kg CO_2/kWhCO_2 Savings=39,420,000MWh×0.4kg CO_2/kWh

CO_2 Savings=15,768,000 tonnes of CO_2 Savings=15,768,000 tonnes of CO_2 a year.

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