ANALYSIS

NIGERIA

Sector Analysis Nigeria

Renewable heat supply and process heat solutions for the C&I sector

Deutsche Gesellschaft
für Internationale
Zusammenarbeit (GIZ) GmbH

This publication was commissioned by the German Energy Solutions Initiative of the German Federal Ministry for Economic Affairs and Energy (BMWE)

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Abbreviations/acronyms

CAPEX	Capital expenditure
CHP	Combined heat and power
CNG	Compressed natural gas
C&I	Commercial and industrial
EPSRA	Electric Power Sector Reform Act
ESCOs	Energy service companies
FMEnv	Federal Ministry of Environment
GDP	Gross domestic product
IEA	International Energy Agency
IPP	Independent power producer
IRR	Internal rate of return
NBS	Nigerian Bureau of Statistics
NEP	Nigeria's National Energy Policy
NERC	Nigerian Electricity Regulatory Commission
NIPC	Nigerian Investment Promotion Commission
NPC	National Population Commission
NPV	Net present value
NREAP	National Renewable Energy Action Plan
NREMP	Nigerian Renewable Energy Master Plan
OLS	Ordinary least squares
OPEX	Operating expenditure
P2H	Power-to-heat
PIA	Petroleum Industry Act
PV	Photovoltaic
REA	Rural Electrification Agency
ROI	Return on investment
REMP	Renewable Energy Master Plan
TRL	Technology readiness level
WHR	Waste heat recovery

Currency units

NGN	Naira
EUR	Euro

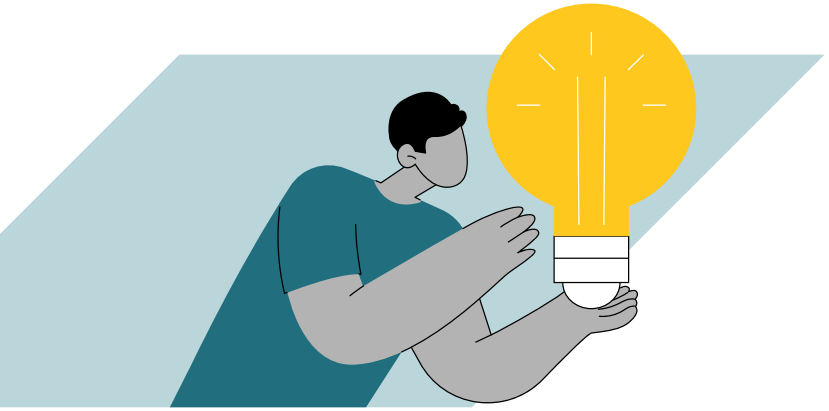
Currency units and conversion rate as of 21.06.2025

NGN 1 = EUR 0.00056
EUR 1 = NGN 1787.10

Source: www.worldcurrencylist.com/germany/euro/eur/

Technical units

GJ	Gigajoule
GWh	Gigawatt hour
kWp	Kilowatt peak
mm	Millimetres
MWh	Megawatt hour



ENERGY SOLUTIONS – MADE IN GERMANY

The German Energy Solutions Initiative

The German Energy Solutions Initiative of the German Federal Ministry for Economic Affairs and Energy (BMWE) aims to globalise German technologies and expertise in climate-friendly energy solutions.

Years of promoting smart and sustainable energy solutions in Germany have led to a thriving industry known for world-class technologies. Thousands of specialised small and medium-sized enterprises (SMEs) focus on developing renewable energy systems, energy efficiency solutions, smart grids, and storage technologies. Cutting-edge energy solutions are also built on emerging technologies such as power-to-gas, fuel cells, and green hydrogen. The initiative's strategy is shaped around ongoing collaboration with the German business community.

The initiative creates benefits for Germany and the partner countries by:

- boosting global interest in sustainable energy solutions
- encouraging the use of renewables, energy efficiency technologies, smart grids, and storage technologies, while facilitating knowledge exchange and capacity building
- enhancing economic, technical and business cooperation between Germany and partner countries

THE PROJECT DEVELOPMENT PROGRAMME (PDP)

PDP is a key pillar of the German Energy Solutions Initiative and is implemented by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. It connects development cooperation with private-sector engagement and supports climate-friendly energy solutions in selected developing and emerging countries, enabling local businesses to adopt solutions in energy efficiency, electricity and heat supply, and hydrogen, while facilitating market access for German solution providers.

Developing and emerging economies offer promising business potential for climate-friendly energy solutions but also pose challenges for international business partners. The PDP team works closely with local industries to develop financially viable projects by providing technical expertise, financial guidance, and networking opportunities.

It identifies project leads, collects and analyses energy consumption data, and assesses projects from both a technical and economic perspective. This includes outlining the business case, calculating payback periods, and evaluating profitability. Companies can then choose to finance projects using their own funds or explore leasing and other financing options. PDP provides cost-free advice to local companies and connects them with German solution providers for project implementation.

Additionally, by offering training, organising reference project visits, and publishing studies on the potential of climate-friendly solutions and on navigating regulatory frameworks, the programme supports market development and fosters private-sector cooperation.

Executive summary

HIGH-GROWTH RETURNS IN NIGERIA'S RENEWABLE HEAT SECTOR

Nigeria renewable energy sector offers a highly promising, rapidly growing market for renewable heat and heat process solutions, presenting significant untapped potential and attractive long-term returns for solution providers based in Germany.

The analysis points to a burgeoning demand within the Commercial and Industrial (C&I) sector, fuelled by persistent grid instability and a critical need for reliable, decentralized energy. This dynamic environment, ripe for innovation, creates a unique opportunity, especially for solution providers leveraging German engineering and technological expertise.

UNLOCKING MARKET POTENTIAL WITH PROVEN TECHNOLOGIES

The Nigerian market is uniquely positioned for high-growth entry points in Solar Thermal Systems, Biomass Boilers and Combined Heat and Power (CHP). Nigeria's abundant solar resources and expansive agro-industrial sector, with its substantial energy demands, align perfectly with the proven efficiency and technological superiority of German technologies solutions. Investing in decentralized applications directly addresses Nigeria's critical energy supply gaps, presenting a prime market segment for immediate impact and scalable growth.

Zusammenfassung

HOHES WACHSTUMSPOTENZIAL IM BEREICH ERNEUERBARE PROZESSWÄRME IN NIGERIA

Der nigerianische Markt für Lösungen mit erneuerbaren Energien im industriellen Prozesswärmesektor entwickelt sich rasant. Für Lösungsanbieter mit Sitz in Deutschland bietet er erhebliche, bislang ungenutzte Potenziale und attraktive langfristige Chancen auf Rendite.

Die vorliegende Analyse beweist die stark wachsende Nachfrage insbesondere im „Commercial & Industrial (C&I)"-Sektor, angetrieben durch die anhaltend instabile Stromversorgung und den dringenden Bedarf an zuverlässiger, dezentraler Energie. In diesem dynamischen Umfeld eröffnen sich Chancen für innovative Lösungen, insbesondere für Anbieter, die auf deutsche Ingenieurskunst und Technologiekompetenz setzen.

MIT ERPROBTEN TECHNOLOGIEN MARKTPOTENZIALE ERSCHLIESSEN

Der nigerianische Markt bietet ideale Voraussetzungen für starkes Wachstum in den Bereichen Solarthermie, Biomassekessel und Kraft-Wärme-Kopplung (KWK). Hier treffen starke Sonneneinstrahlung und ein breit aufgestellter agroindustrieller Sektor mit erheblichem Energiebedarf auf die erwiesenermaßen große Effizienz und die führenden Technologien deutscher Anbieter.

Investitionen in dezentrale Anwendungen setzen dort an, wo Nigerias Energieversorgung lückenhaft ist. Das eröffnet Anbietern einen vielversprechenden Markt mit unmittelbarem Wirkungs- und hohem Skalierungspotenzial.

NAVIGATING CHALLENGES FOR STRATEGIC INVESTMENT

While Nigeria's investment climate is improving and the government actively seeks renewable heat solutions, strategic navigation of challenges is crucial. These include foreign exchange volatility, policy uncertainties, and financing limitations. We advocate for rigorous due diligence and comprehensive risk assessment, coupled with the development of robust mitigation strategies encompassing political, economic, regulatory, operational, community, and financial considerations.

PATHWAYS TO MARKET ENTRY AND LONG-TERM SUCCESS

To secure successful market entry and long-term returns in Nigeria's renewable heat and process heat sector, private investors must strategically cultivate trust-based partnerships with established local entities to effectively navigate the intricate business landscape. Concurrently, leveraging financial expertise to develop innovative financing models will significantly boost adoption among the growing Nigerian end-users.

Also, emphasizing a long-term investment approach, with compelling cost-saving benefits and operational efficiencies of German technology, will resonate strongly with Nigerian industries. Potential investors are expected to be highly committed to technology transfer and local capacity building to foster long-term project viability, enhance social license to operate, and mitigate future risks.

HERAUSFORDERUNGEN STRATEGISCH MEISTERN – FÜR NACHHALTIGE INVESTITIONEN

Auch wenn sich das Investitionsklima in Nigeria zunehmend bessert und die Regierung nach Lösungen im Bereich erneuerbare Wärme sucht, ist eine strategische Herangehensweise entscheidend, um Herausforderungen zu bewältigen. Dazu zählen die Wechselkursvolatilität, politische Unsicherheiten und begrenzte Finanzierungsmöglichkeiten. Daher empfehlen wir eine gründliche Due-Diligence-Prüfung und eine umfassende Risikobewertung, ergänzt um belastbare Strategien zur Risikominderung. Die Strategien sollten politische, wirtschaftliche, regulatorische, operative, gesellschaftliche und finanzielle Aspekte gleichermaßen berücksichtigen.

WEGE ZUM MARKTEINTRITT UND LANGFRISTIGEN ERFOLG

Im nigerianischen Markt für erneuerbare Prozesswärme entscheiden vertrauensvolle Partnerschaften mit etablierten lokalen Akteuren über den erfolgreichen Einstieg und nachhaltige Renditen. Die Partnerschaften ermöglichen eine effektive Orientierung in einem komplexen Geschäftsumfeld. Gleichzeitig kann unter anderem fundiertes Finanz-Know-how die Entwicklung innovativer Finanzierungsmodelle fördern und die Nachfrage bei den größer werdenden Nutzergruppen in Nigeria erheblich steigern.

Ein langfristig angelegter Investitionsansatz, der die Kostenvorteile und Betriebseffizienz deutscher Technologie betont, stößt auf großes Interesse in der nigerianischen Industrie. Erwartet wird ein hohes Engagement der Investoren für den Technologietransfer und den Kompetenzaufbau vor Ort. Das Engagement ist essenziell für die Tragfähigkeit von Projekten und deren gesellschaftliche Akzeptanz und auf lange Sicht die Risikominimierung.

BUSINESS OPPORTUNITIES FOR GERMAN SOLUTION PROVIDERS

The Nigerian government's explicit recognition of the strategic importance of renewable heat and process heat solutions underscores the urgency and potential of this sector. By understanding market dynamics, proactively addressing challenges, and embracing these strategic recommendations, potential investors and particularly German private sector investors have an unparalleled opportunity to become strategic players in unlocking Nigeria's immense renewable heat and process heat potential. This will not only contribute significantly to Nigeria's sustainable industrialization but also deliver attractive, enduring returns in one of Africa's most dynamic and rapidly expanding economies.

GESCHÄFTSMÖGLICHKEITEN FÜR DEUTSCHE LÖSUNGSANBIETER

Die Anerkennung der strategischen Bedeutung von Lösungen mit erneuerbarer Wärme- und Prozesswärme durch die nigerianische Regierung unterstreicht sowohl die Dringlichkeit als auch das enorme Potenzial des Sektors. Wer die Marktdynamiken versteht, Herausforderungen proaktiv angeht und die genannten strategischen Empfehlungen berücksichtigt, kann eine Schlüsselrolle bei der Erschließung dieses vielversprechenden Marktes übernehmen –insbesondere als deutscher Investor.

Investoren leisten einen wichtigen Beitrag zur nachhaltigen Industrialisierung Nigerias und sichern sich zugleich attraktive und langfristige Renditen in einer der dynamischsten und wachstumsstärksten Volkswirtschaften Afrikas.

1

Country Profile

1.1 Introduction to Nigeria

Nigeria has huge untapped potentials, with its vibrant industries and growing population offering a compelling and timely landscape for energy sector investors. This sector analysis delivers critical insights into Nigeria's process heat solutions market, detailing the needs of key sectors like food, beverage, agriculture, and manufacturing. It examines how economic policies and political stability shape market growth, alongside the significant influence of demographic trends and geographical factors on energy demand and operational strategies. By providing a detailed understanding of the Nigerian context, this report acts as a vital guide for capitalising on the substantial opportunities within its promising energy market.

TABLE 1. Summary of country profile

SN	Thematic area	Key metrics
1	Geography and climate	**Geography:** Nigeria extends roughly 1,200 km (east-west) and 1,050 km (north-south), exhibiting a varied topography from the southern Niger Delta lowlands to the central hills and plateaus. Its tropical climate features distinct wet and dry seasons with regional variations. The nationwide average annual temperature is approximately 27°C, with lower thermal amplitude in the south compared to the north.
2	Economy	**Gross domestic product (GDP):** Nigeria's economic performance over the years has been characterised by periods of growth and decline. The decreasing contribution of oil and gas to GDP underscores the urgency for economic diversification. According to a March 2022 article by Andersen Global (2022), harnessing renewable energy sources therefore presents a viable pathway for sustainable economic growth, with projections indicating a potential average annual GDP growth rate of 7.0% from 2025 to 2035, contingent upon full implementation of renewable energy initiatives. **Geothermal energy:** Nigeria's geological setting largely precludes high-enthalpy geothermal energy generation; however, a review from Sakinat Damare Abubakar, (2024) noted that there is an untapped, but low-enthalpy, geothermal potential for direct-use applications from warm springs and, more significantly, for widespread adoption of ground source heat pumps (GSHPs). Olatunji, et al., (2010) also noted that exploring this potential requires dedicated geological surveys, capacity building, supportive policy frameworks, and increased awareness to attract German investment and facilitate technology transfer. Focusing on direct-use applications and GSHPs presents a practical and environmentally sound pathway for leveraging Nigeria's subsurface heat.

Table 1 contains a summary profile of Nigeria. The country stands at the cusp of an economic transformation, poised to leverage its vast renewable energy potential for significant GDP growth and diversification. The strategic implementation of a comprehensive renewable energy policy framework, targeting at least 30% integration by 2030, presents a compelling opportunity to reduce reliance on traditional oil and gas sectors. This shift will not only foster sustainable economic growth, projected at an impressive average annual rate of 7.0% post-2025, but also unlock new avenues for job creation and technological advancement across the renewable energy value chain.

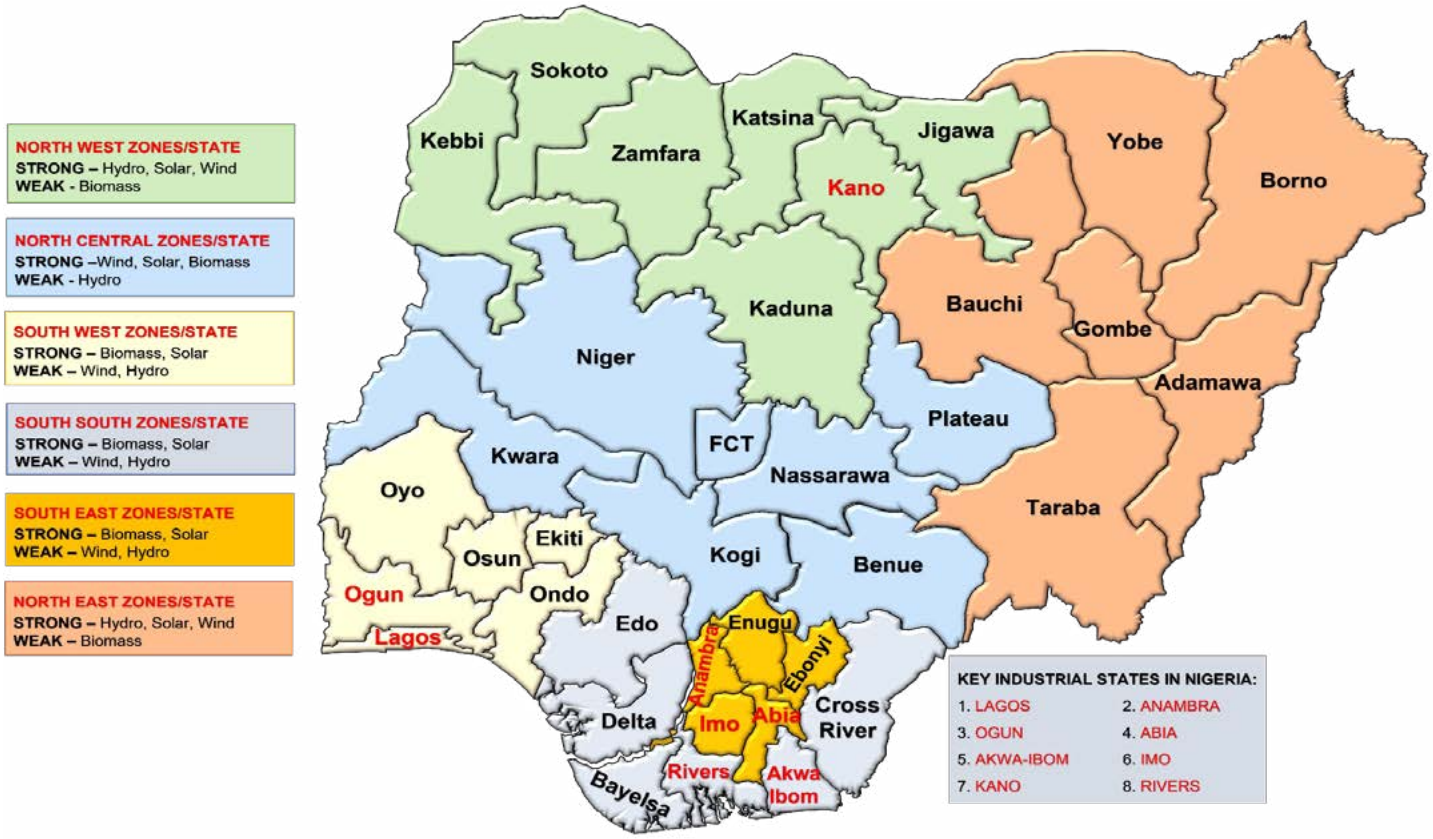
SN	Thematic area	Key metrics
3	**Demography**	**Energy demand:** According to a publication by IRENA, (2023) Nigeria has over 220 million people and vast ethnic diversity, experiencing rising energy demands driven by a young population. The 0–14 age group (42%) has the highest need, making early renewable energy investment crucial for future growth and education. The 15–24 group (20%) also requires significant energy as they enter adulthood. The 25–64 workforce (35%) benefits from renewables through improved productivity. Though the 65+ group (3%) have lower needs, inclusive planning ensures no one is left behind. Demographic-focused energy strategies are key to a sustainable future.
4	**Political landscape**	Nigeria's political landscape is marked by democratic aspirations challenged by electoral disputes, ethnic and religious divisions, and severe security threats. Political instability, corruption, and inconsistent policies create an uncertain investment climate, deterring large-scale projects.
5	**Policy milestones**	Nigeria has made strides in repositioning its energy sector through key policies. These include the overarching National Energy Policy (NEP), the renewable energy-focused National Renewable Energy Master Plan (NREMP), the Electric Power Sector Reform Act (EPSRA) (2005), and the oil and gas-centric Petroleum Industry Act (PIA) (2021). This was corroborated with our survey on policy effectiveness, which indicates high perceived success for the NEP and state-level renewable energy policies, but lower ratings for the Nigeria Energy Efficiency Policy (NEEP) and Gas Policy, emphasising the need for better alignment, particularly for renewable energy. The Energy Transition Plan (ETP) shows moderate effectiveness.

Source: Authors' own compilation, Infratec Environmental Technologies (2025) based on IRENA (2023), Renewable Energy Roadmap: Nigeria, International Renewable Energy Agency, Abu Dhabi

By strategically harnessing solar, wind, and other renewable resources, Nigeria can power its burgeoning industries, enhance energy access for its youthful population, and attract foreign direct investment in green technologies.

Figure 1 provides a concise overview of renewable energy investment opportunities across Nigeria's six geopolitical zones. The North West and North East zones stand out for their diversified potential, boasting strong resources in hydro, solar, and wind, making them attractive for large-scale solar photovoltaic (PV) and wind farm developments. The North Central zone offers strong solar and wind resources, complemented by significant biomass potential, particularly appealing for agro-industrial energy solutions. The South West and South East zones are well-suited for biomass and solar energy projects, with the South West also presenting potential for waste-to-energy initiatives near urban centres. Finally, the South-South zone aligns strongly with biomass and solar energy investments. The map also highlights areas with high industrial presence. This breakdown allows investors to quickly identify regions with the most promising renewable energy resources aligned with their specific technology focus.

FIGURE 1. Renewable energy distribution across regions



Source: Authors' own compilation, Infratec Environmental Technologies (2025), based on (Okedu et al., 2015)

2

Market Opportunities in The Country

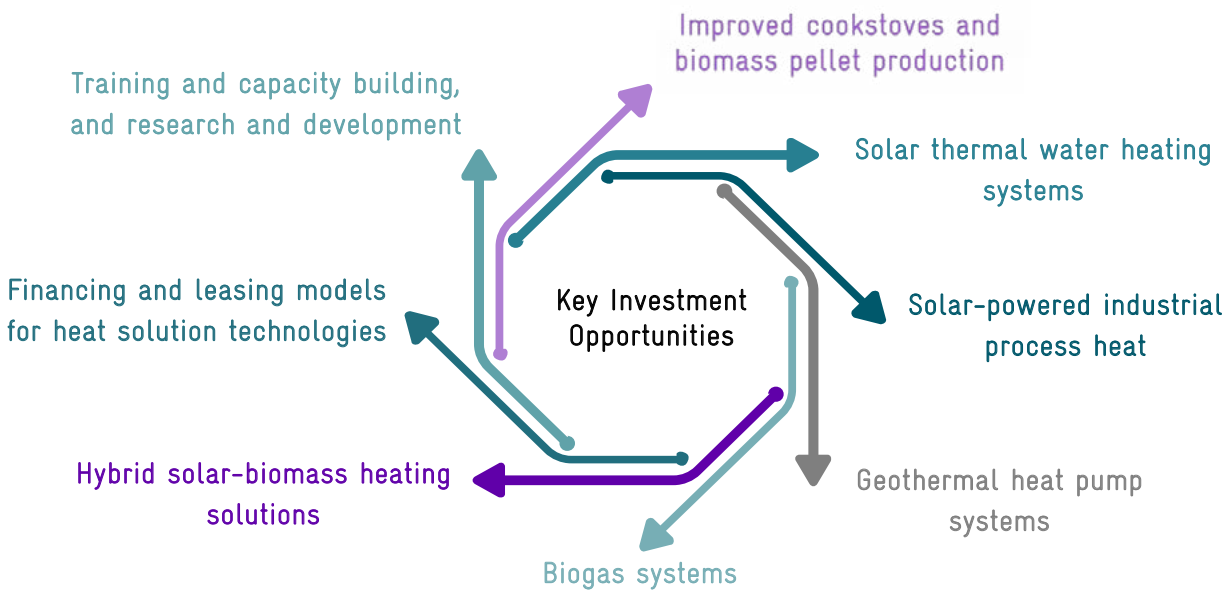
2.1 Current status and key investment opportunities in renewable heat and process heat solutions

Renewable heat and process heat applications in Nigeria are currently limited, primarily involving biomass for cooking and drying in rural areas, while solar thermal systems are increasingly used for water heating in buildings but remain underutilised for industrial process heat. Furthermore, geothermal energy potential is largely untapped (Nwankwo, 2021), and energy efficiency measures in process heat applications are generally poorly adopted.

Key investment opportunities in heat energy solutions centre around transitioning from traditional, harmful practices to sustainable, efficient technologies. These opportunities span various sectors and offer both financial returns and a positive social and environmental impact.

Figure 2 outlines a strategic approach to fostering investment in the renewable heat and process heat solution sector. It highlights that investment opportunities are multifaceted, encompassing not only the direct deployment of diverse renewable heat technologies but also crucial enabling mechanisms. These enabling mechanisms, including innovative financing and leasing models for these technologies, alongside dedicated training, capacity building, and robust research and development, form a vital supportive ecosystem. The interconnected nature of these elements suggests that successful investment in the sector hinges on a holistic strategy that integrates technological advancement with accessible financial frameworks and a skilled workforce, thereby accelerating the transition to sustainable heat solutions.

FIGURE 2. Key investment opportunities in renewable heat and heat process solutions



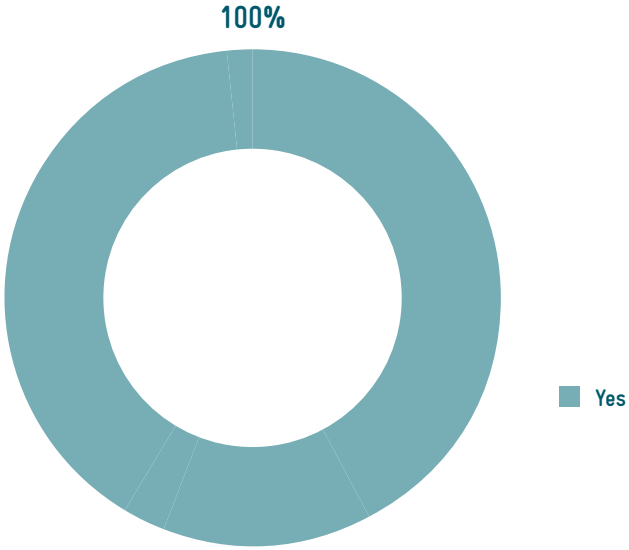
Source: Authors' own illustration, Infratec Environmental Technologies (2025), based on (Kenu et al., 2023)

2.1.1 Investment and partnership opportunities in renewable heat and process heat solutions

The investment and partnership climate in Nigeria's renewable heat and process heat sector is characterised by increasing interest and potential, driven by the nation's vast renewable resources and the urgent need to address energy deficits. Government policies, such as the Renewable Energy and Energy Efficiency Policy, aim to attract investment, and international collaborations, like those with the World Bank and African Development Bank, are fostering project development. However, challenges persist, including infrastructural limitations, regulatory hurdles, and financing gaps. Nevertheless, the growing involvement of private sector entities, coupled with philanthropic support aimed at de-risking projects, signals a promising growth trajectory for renewable heat and process heat solutions growth in Nigeria.

Figure 3 demonstrates a unanimous 100% positive response towards partnering with German investors. This indicates an exceptionally high level of willingness and receptiveness among the relevant stakeholders for German renewable heat and process heat solutions for collaborative ventures, signifying a very strong foundation for future partnerships.

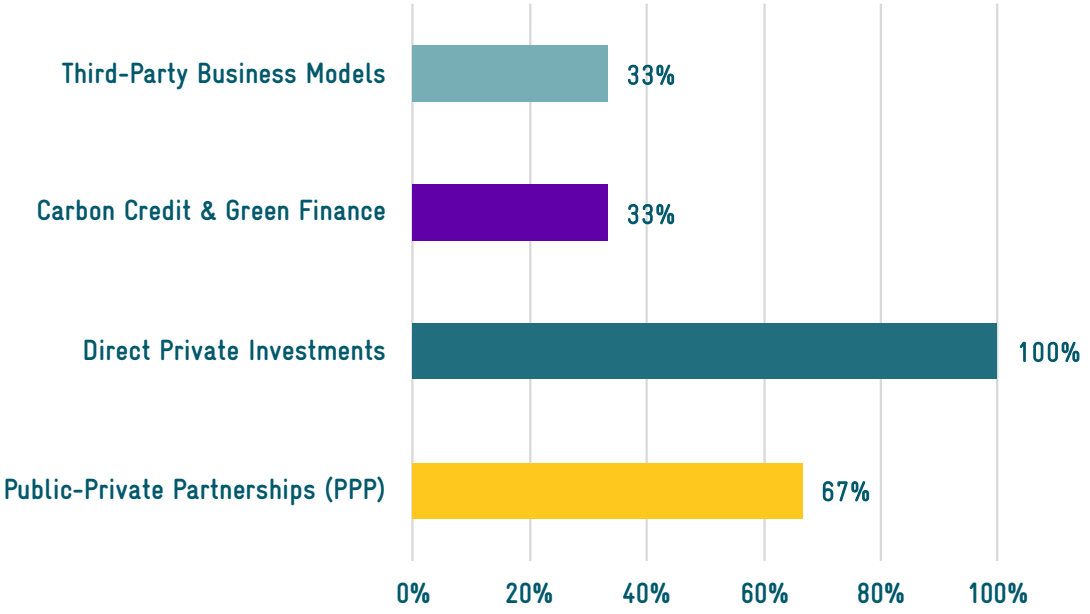
FIGURE 3. Collaboration with partners/investors



Source: Authors' own illustration, Infratec Environmental Technologies (2025) based on completed survey questionnaires (2025)

As Figure 4 shows, a key indicator of investor confidence is the dominance of direct private investments, accounting for 100% of the surveyed models. This highlights a maturing market and a willingness to commit capital directly. Public-private partnerships (PPPs) also play a crucial role, representing 67% of the models, demonstrating the importance of collaborative efforts in overcoming financing obstacles and leveraging combined resources. The emergence of third-party business models, at 33%, showcases innovative approaches to address upfront costs, potentially through leasing or power purchase agreements, broadening access to renewable heat and process heat solutions. Furthermore, the adoption of carbon credit and green finance, also at 33%, reflects a growing commitment to sustainability within the sector. This indicates an increasing awareness of the environmental benefits of renewable heat and process heat solutions and the potential for carbon offsetting projects. The diverse range of investment models highlights the flexibility and adaptability of the sector in navigating the challenges and opportunities presented by Nigeria's energy landscape.

FIGURE 4. Investment models



Source: Authors' own illustration, Infratec Environmental Technologies (2025) based on completed survey questionnaires (2025)

2.2 Key market drivers for sustainable energy solutions

Nigeria, with its rapidly growing population and vast energy needs, presents a compelling case for the adoption of sustainable energy solutions. The nation's current reliance on fossil fuels faces increasing challenges, including environmental concerns, grid instability, and the need to power remote communities. Therefore, understanding the key market drivers that are pushing Nigeria towards embracing renewable energy sources is crucial for both investors and policymakers aiming to foster a sustainable and prosperous energy future.

The burgeoning market for sustainable energy solutions in Nigeria is primarily driven by a critical need to overcome the nation's unreliable grid supply and meet the escalating energy demands of its economic growth and industrialisation. Rising fuel costs further underscore the economic viability of sustainable alternatives, aligning with Nigeria's sustainability goals and a growing awareness of environmental concerns. This transition is significantly bolstered by supportive government policies and initiatives, coupled with ongoing technological advancements and increasing affordability of renewable energy solutions. The sector also benefits from increased access to financing and investment, offering pathways to enhance energy access and reliability for underserved communities while delivering tangible health benefits through reduced pollution and catering specifically to the stable and substantial power requirements of the growing commercial and industrial sector.

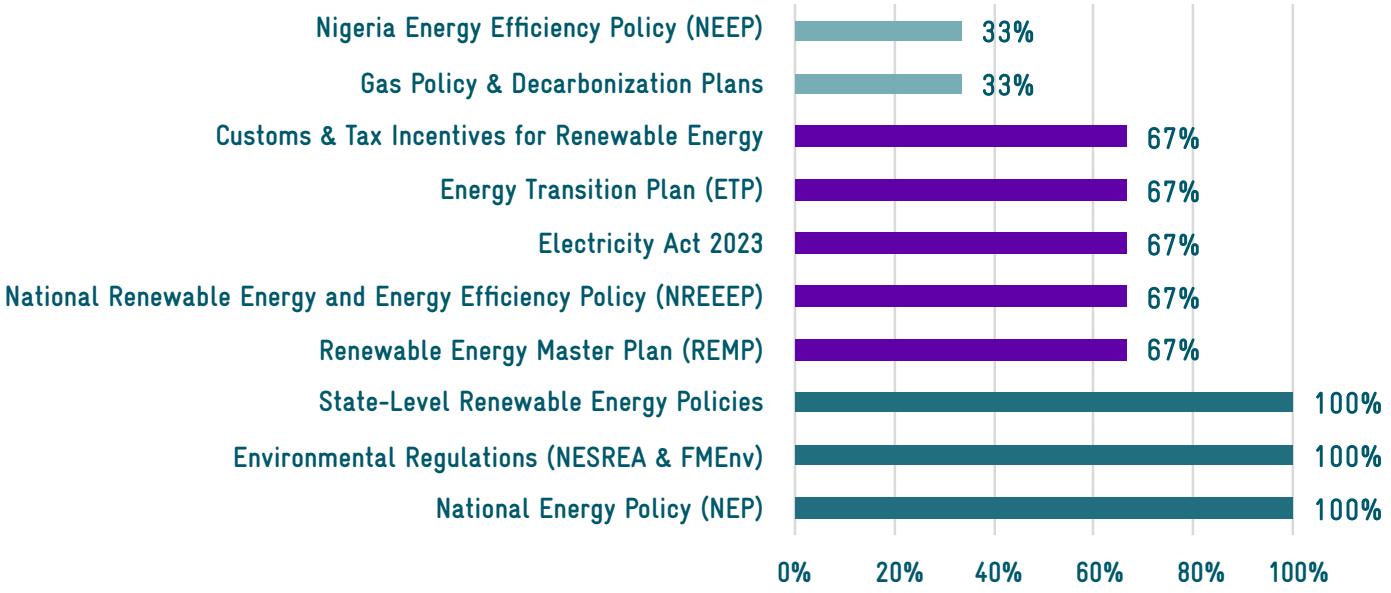
The future of renewable heat and process heat energy in Nigeria is inextricably linked to sustainable solutions. This imperative is fuelled by critical drivers including robust economic expansion, rising fuel costs, strong environmental commitments, enabling government policies, grid unreliability, and technological advancements. All these are underpinned by the pervasive demand for reliable and accessible energy across sectors.

2.3 Legal framework and energy policies

Nigeria's energy landscape is guided by a series of strategic policies and legislative acts designed to address its complex needs and promote sustainable development. These frameworks aim to diversify the energy mix, incentivise renewable energy adoption, and improve overall sector efficiency, while navigating the challenges of privatisation and the evolving role of the petroleum industry.

As shown in the chart in Figure 5, the National Energy Policy (NEP), environmental regulations (NESREA & FMEnv), and state-level renewable energy policies possess strong policy enforceability and are significant regulatory mechanisms as indicated by the level of effectiveness of the policy being 100%. Following these, the Renewable Energy Master Plan, National Renewable Energy and Energy Efficiency Policy, Electricity Act 2023, and Energy Transition Plan possess moderate enforceability and incorporate fiscal incentives. The customs & tax incentives for renewable energy, too, explicitly focus on fiscal incentives, suggesting moderate enforceability through tax administration. The Nigeria Energy Efficiency Policy and Gas Policy & Decarbonisation Plans represent the weakest level of enforceability and implementation of fiscal incentives such as tax breaks compared to the others.

FIGURE 5. Regulatory and policy frameworks



Source: Authors' own Illustration, Infratec Environmental Technologies (2025) based on completed survey questionnaires (2025)

2.4 Economic opportunities and key benefits in renewable heat and process heat solutions

The significance of renewable heat and process heat solutions in Nigeria cannot be overstated, especially in light of the challenges of climate change, dwindling fossil fuel reserves, and the urgent need for sustainable development. This is not just about reducing the carbon footprint, it is about ensuring a stable energy future for generations to come.

The economic benefits of renewable heat and process heat solutions are becoming increasingly evident, particularly for a nation like Nigeria, where energy scarcity has hindered growth. By investing in renewable heat and process heat sources such as solar, wind, and biomass, Nigeria can significantly decrease its reliance on fossil fuels, which are not only expensive but also subject to price volatility. Transitioning to renewable heat and process heat solutions can promote energy independence while also enhancing the stability of energy costs for both businesses and households.

Furthermore, the renewable energy sector has demonstrated its capacity to create jobs. As investment is injected into infrastructure for solar farms and wind turbines, Nigeria is not only generating power but also creating employment opportunities in construction, maintenance, and technology sectors. This job creation can trigger a ripple effect throughout the economy, leading to increased local spending and improved living standards.

In addition, investments in renewable heat and process heat solutions can attract international funding and partnerships, which can facilitate technology transfer and skill development. By aligning itself with global sustainability trends, Nigeria can position itself as a leader in the energy sector, enhancing its economic appeal for German investment.

Lastly, renewable heat and process heat solutions facilitate long-term cost savings. Although the initial investment may appear substantial, the operational costs are generally lower compared to conventional energy sources. This cost-effectiveness can provide significant advantages for public utilities and, ultimately, consumers.

3

Overview of Nigeria's Energy Sector

3.1 The energy sector

Nigeria's energy sector is a diverse mix of conventional and renewable resources, with natural gas being the dominant energy source, primarily used for electricity generation. The country holds one of the largest natural gas reserves in Africa, alongside significant crude oil deposits. Despite this abundance, energy access remains limited, especially in rural areas, due to infrastructure and distribution challenges. Renewable heat and heat process solutions such as solar, hydro, biomass, and wind also hold vast potential but remain largely underutilised. The sector is currently undergoing reforms aimed at improving efficiency, sustainability, and energy access for all.

3.1.1 Thermal energy in Nigeria

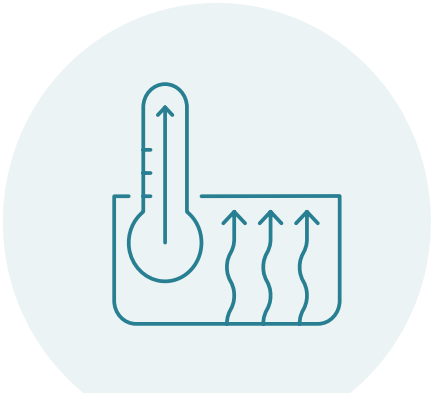
Nigeria's thermal energy landscape is deeply rooted in its abundant fossil fuel reserves, particularly natural gas and crude oil, which power a significant portion of the country's electricity generation. Thermal power plants, predominantly gas-fired, contribute more than 70% of the nation's grid electricity (Aliyu, Ramli, & Saleh, 2013). Despite this dominance, Nigeria struggles with energy supply inconsistencies due to poor infrastructure, inadequate gas supply, and operational inefficiencies. The country has an installed generation capacity exceeding 13,000 MW, but available capacity often falls below 5,000 MW, largely due to transmission constraints and frequent plant outages (Nigerian Electricity Regulatory Commission [NERC], 2024).

In rural and peri-urban areas, biomass serves as a primary thermal energy source, especially for cooking and heating. Over 70% of households rely on traditional biomass such as firewood and charcoal, often using open fires or rudimentary stoves (Oyedepo, 2012). This mode of thermal energy use is not only inefficient but also poses significant health and environmental risks, including indoor air pollution and deforestation. The deployment of improved cookstoves and biogas systems remains limited, though they present viable alternatives for clean and sustainable thermal energy.

Solar thermal energy presents another untapped opportunity in Nigeria's thermal landscape. With average daily solar radiation levels ranging from 5.5 to 7.0 kWh/m^2/day, the country is well-positioned to harness solar heat for water heating, crop drying, and light industrial applications (Bugaje, 2001). However, the use of solar thermal technologies remains minimal compared to solar photovoltaic systems, which have received more attention in off-grid electrification programmes. Factors such as lack of technical know-how, insufficient policy incentives, and weak market structures have contributed to the neglect of solar thermal development in national energy planning (Federal Ministry of Power, 2015).

Geothermal thermal energy remains largely unexplored in Nigeria. While preliminary studies suggest the existence of low-enthalpy geothermal resources in regions such as the Benue Trough and Jos Plateau (Olatunji et al., 2010), no significant exploration or development has been undertaken. The absence of geothermal-specific policies, along with limited geological data, hinders investment and research in this area.

Overall, Nigeria's thermal energy landscape is marked by heavy dependence on conventional sources, underutilisation of renewable thermal technologies, and an urgent need for integrated policy frameworks to support diversification and sustainability.



3.2 The commercial and industrial (C&I) sector

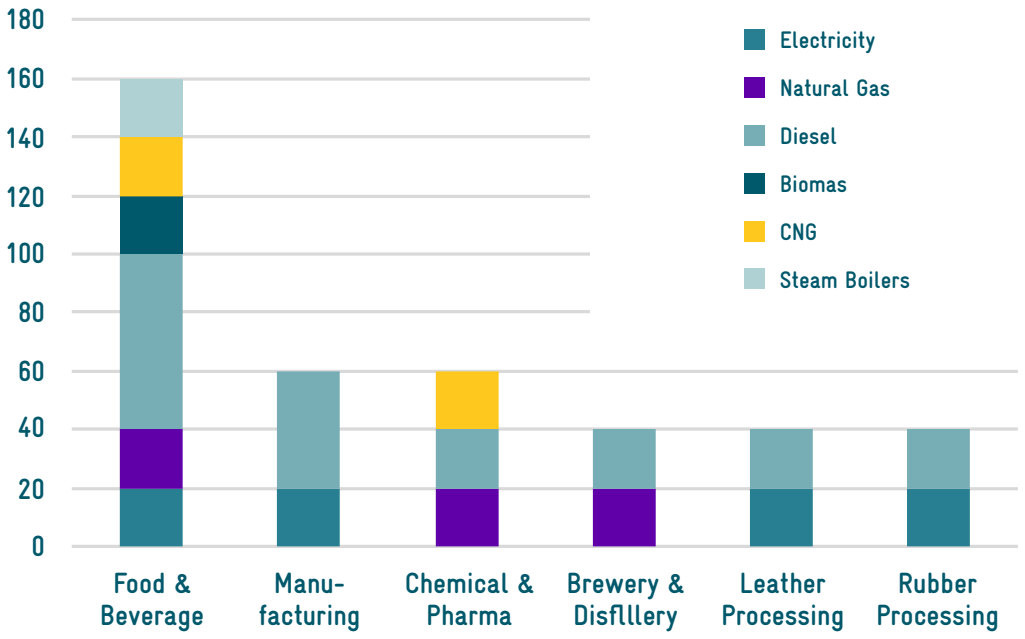
In Nigeria, the commercial sector primarily includes businesses involved in trade, services, and administration, such as retail outlets, shopping malls, hotels, hospitals, educational institutions, office complexes, and public administrative buildings. The industrial sector, on the other hand, comprises entities engaged in manufacturing, processing, mining, construction, and other productive enterprises, ranging from small and medium-sized enterprises (SMEs) to large-scale factories and heavy industries. Understanding the specific energy needs and consumption patterns within this broad and dynamic C&I segment is paramount for sustainable energy planning, investment in reliable power solutions, and fostering continued economic growth in Nigeria.

3.2.1 Renewable heat and process heat demand in the C&I sector

The commercial and industrial (C&I) sector in Nigeria is experiencing a surge in energy demand, with reports indicating that annual electricity demand is growing at rates ranging from 10% to 15% or even higher in certain rapidly industrialising regions. This is fuelled by the establishment of new manufacturing plants, expansion of existing businesses, and increased commercial activities. While much attention has been given to electricity access, heat energy remains a fundamental need for both domestic and industrial use (Owusu & Asumadu-Sarkodie, 2016). Thermal energy accounts for approximately 60-70% of final energy consumption in most African countries such as Nigeria, Kenya, Ethiopia, Tanzania, Uganda, Ghana, and Malawi, yet renewable heat and process heat solutions remain underdeveloped (IRENA, 2020).

However, Nigeria's heavy reliance on traditional biomass for heat energy presents a significant challenge. Over 80% of household energy needs are met by firewood, charcoal, and agricultural residues, leading to severe environmental and health consequences. Moreover, inefficient combustion generates substantial indoor air pollution, posing serious health risks, particularly to women and children. This situation underscores the urgent need to transition towards cleaner and more efficient energy solutions to mitigate environmental degradation and safeguard public health.

FIGURE 6. Main sources of heat energy in the C&I sector



Source: Authors' own Illustration, Infratec Environmental Technologies (2025) based on completed survey questionnaires (2025)

Figure 6 shows the common sources of heat energy used in the C&I sector in Nigeria. The analysis indicates that diesel serves as the major source of heat energy in the C&I sector, followed by grid electricity and natural gas. Other sources of heat supply in this sector constitute a smaller percentage of use in total.

3.2.2 Industrial process heat load profile

Nigeria's industrial load profile shows significant baseload and peak demand across various industries. This signals substantial capital expenditure (CAPEX) deployment opportunities in the energy infrastructure. See Annex 4

The heat load variations from Table 2 necessitate strategic investments in grid-scale energy storage and optimised dispatchable generation assets. The "renewable heat and process heat solution match" matrix directs investments towards sector-specific, distributed generation utilising solar thermal, biomass, CHP, CNG, WHR, and heat pump technologies.

TABLE 2. Energy load profile in various industries

Industry	Typical heat processes	Average annual heat expenditure (NGN'million)	Average temp. range (°C)	Average estimated demand	Heat demand rank	Renewable energy match
Food & beverage	Pasteurisation, sterilisation, drying, boiling	10 - 600	100 - 400	10 - 100 + GJ/MWh	Medium to high	WHR, heat pumps, biomass boilers, solar thermal
Chemical & pharma	Drying, mixing, distillation	1 - 100	100 - 250	100 + GJ/MWh	High	Biomass, CHP, solar thermal, heat pumps, CNG
Brewery & distillery	Mashing, boiling, cleaning,	10 - 400	100 - 400	50 - 100 GJ/MWh	Medium	Biomass boilers, solar thermal, CHP, CNG
Manufacturing (cable wire & plastic)	Extrusion, vulcanisation, curing	10 - 400	100 - 150	50 - 100 GJ/MWh	Medium	Solar thermal, CNG, solar power
Processing (leather & bag)	Drying, fixing and setting	1 - 100	100 - 250	10 - 100 GJ/MWh	Medium	CHP biomass boilers, thermal oil systems, solar augmentation
Rubber processing	Vulcanisation, drying, moulding	10 - 400	100 - 400	100 + GJ/MWh	High	Biomass boilers, thermal oil systems, solar augmentation

Source: Authors' own compilation, Infratec Environmental Technologies (2025) based on completed survey questionnaires (2025)

3.2.3 Level of awareness, investment climate and perspective on renewable heat and heat process solutions in the C&I sector

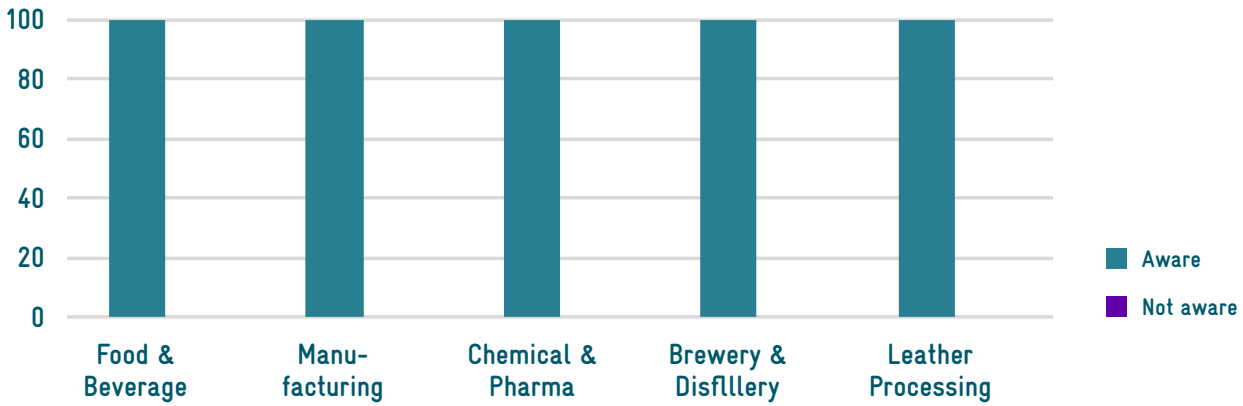
The level of awareness and general perspective on renewable heat and process heat solutions within Nigeria's commercial and industrial (C&I) sector is gradually improving, though it remains relatively low compared to conventional energy alternatives. Most stakeholders in the sector prioritise diesel and electricity access, often overlooking the potential of renewable heat solutions such as solar thermal systems, biomass boilers, and heat pumps for industrial heating processes. Limited technical knowledge, lack of demonstrated case studies, and minimal policy incentives contribute to the low adoption rate. However, growing concerns about energy costs, carbon emissions, and energy security are beginning to shift perspectives, prompting increased interest in integrating clean heat technologies, especially in agro-processing, food and beverage, and manufacturing industries.

3.2.4 Stakeholders' level of awareness

The C&I sector exhibits a growing awareness of and continuous drive towards the adoption of renewable heat and process heat solutions, with alternative energy sources potentially serving as inputs in these processes.

Figure 7 indicates that all listed stakeholders in the C&I sector currently demonstrate about 100% awareness of renewable heat and process heat solution in Nigeria. In essence this implies a highly informed ecosystem poised for potential adoption and investment. With all key players already knowledgeable about the benefits, technologies, and opportunities associated with this solution, the groundwork is laid for swift advancements in its deployment across various sectors, potentially leading to increased investment, supportive policies, and widespread implementation, ultimately contributing to a sustainable energy transition in Nigeria.

FIGURE 7. Level of awareness in the C&I sector



Source: Authors' own illustration, Infratec Environmental Technologies (2025) based on completed survey questionnaires (2025)

3.2.5 Investment climate in Nigeria

The general investment climate in regard to renewable heat and process heat solutions in Nigeria indicates a continuous drive towards the adoption of renewable solutions.

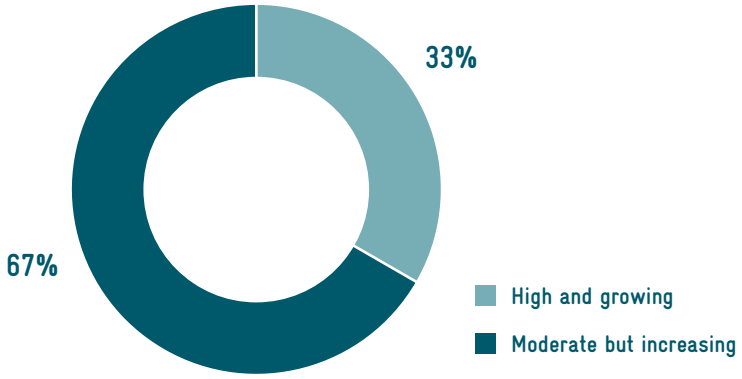
The survey analysis provides a snapshot of the investment climate for renewable energy solutions in Nigeria, specifically highlighting the perspectives of respondents. As illustrated in Figure 8, a significant 67% perceive the climate as 'moderate but increasing', indicating a growing optimism and potential for future expansion. However, a notable 33% already view the climate as 'high and growing', suggesting existing opportunities and a positive outlook for the sector.

3.2.6 Stakeholders' willingness to invest

This analysis highlights the perception of stakeholders in terms of their willingness to adopt renewable heat and heat process solutions in their operations.

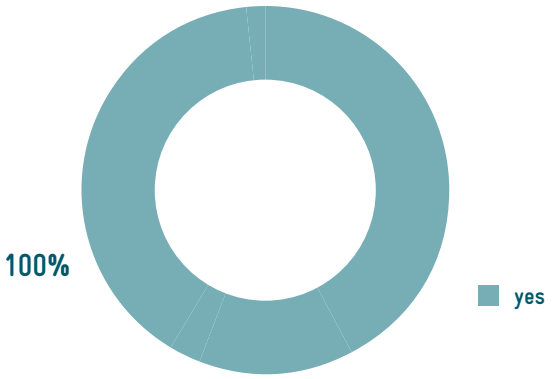
Figure 9 provides a snapshot of the perception of stakeholders in regard to their willingness to invest in renewable heat and heat process solutions in Nigeria. As illustrated in the chart, a significant 100% indicate high interest in investing in the sector.

FIGURE 8. Investment climate for renewable heat and heat process solutions in Nigeria



Source: Authors' own illustration, Infratec Environmental Technologies (2025) based on completed survey questionnaires (2025)

FIGURE 9. Stakeholders' willingness to invest



Source: Authors' own illustration, Infratec Environmental Technologies (2025) based on completed survey questionnaires (2025)

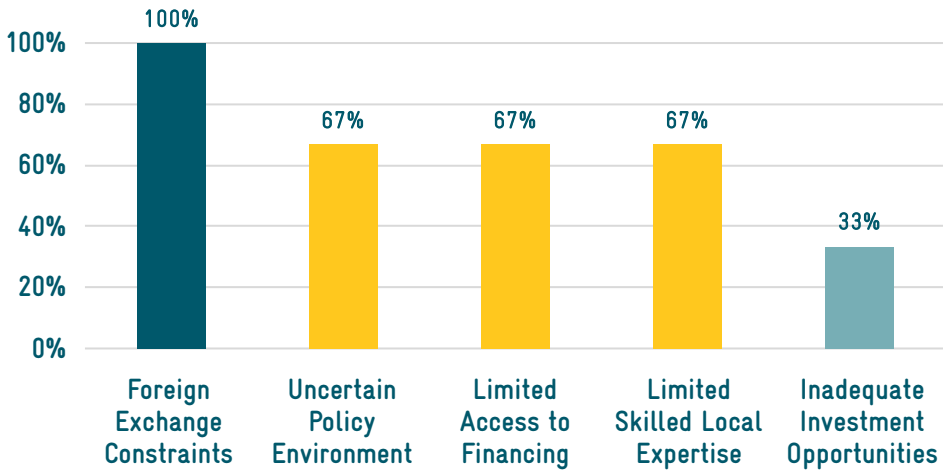
3.2.7 Challenges in renewable heat and process heat investments in Nigeria

Investing in heat solutions in Nigeria faces several critical challenges that hinder its growth and mainstream adoption. Key issues include limited access to financing, insufficient policy support, and a general lack of awareness among investors and end-users. Technical capacity gaps and the absence of localised data on renewable heat potential further discourage large-scale investment. Additionally, the dominance of subsidised fossil fuels reduces the competitiveness of renewable alternatives. Addressing these barriers is essential to unlocking the sector's full potential.

As shown in Figure 10, the Infratec Environmental Technologies survey report analysis reveals the primary obstacles hindering renewable energy investment in Nigeria, with 'foreign exchange constraints' cited by a unanimous 100% of respondents as the most significant challenge. Other substantial hurdles include an 'uncertain policy environment,' 'limited access to financing,' and 'limited skilled local expertise,' each identified by 67% of respondents, indicating systemic issues that require urgent attention. While 'investment opportunities' were perceived as less problematic, at 33%, the overall picture suggests a complex landscape for potential investors.

For Nigeria, these findings underscore the imperative for comprehensive policy reforms to attract renewable energy investment. Establishing a stable and predictable foreign exchange regime, coupled with clear, consistent, and long-term energy policies, is crucial. Furthermore, strengthening the financial sector to provide tailored financing mechanisms and investing in human capital development through targeted education and training programmes are essential to overcome the identified challenges. Promoting existing investment opportunities through feasibility studies and project pipeline development can also enhance market attractiveness.

FIGURE 10. Challenges facing renewable energy investment in Nigeria



Source: Authors' own Illustration, Infratec Environmental Technologies (2025) based on completed survey questionnaires (2025)

4

Market Analysis of Nigeria's Energy Sector – Key Players and Target Groups

4.1 Key stakeholders

The key players in the renewable energy sector in Nigeria are shown on the right in a power-interest matrix.

Table 3 contains stakeholder analysis which categorises various entities based on their level of power and interest. This analysis provides a strategic framework for resource allocation and relationship management. For business and investment decisions, it is crucial to prioritise engagement with high-power, high-interest stakeholders, as their support or opposition can significantly impact project outcomes. Maintaining positive relationships with high-power, low-interest groups is also important to mitigate potential risks. By understanding the influence and interests of each stakeholder group, businesses can tailor their communication and engagement strategies to maximise support and minimise resistance, ultimately enhancing the likelihood of success.

TABLE 3. Stakeholder power-interest analysis

	Low interest	High interest
High power	**Keep satisfied** **1. Public sector** • Federal Ministry of Finance • Federal Ministry of Lands, Housing and Urban Development • Nigeria Customs Service (NCS) • National Council on Climate Change (NCCC)	**Manage closely** **1. Financial institutions** • World Bank • Central Bank of Nigeria (CBN) • Bank of Industry (BoI) **2. Public authorities** • National Agency for Science and Engineering Infrastructure (NASENI) • Energy Commission of Nigeria (ECN) • NMDPRA **3. Trade associations and professional bodies** • Manufacturers Association of Nigeria (MAN) • Nigerian Society of Engineers (NSE)
Low power	**Monitor (minimum effort)** **1. Others** • General public (urban areas) • Uninformed rural population • International tourists • Certain ministries, departments and agencies, such as culture and foreign affairs • Non-energy related businesses	**Keep informed** **1. Financial institutions** • First Bank of Nigeria • United Bank for Africa (UBA) **2. Research institutions** • Delta State University • University of Lagos • Bayero State University • Federal University of Petroleum Science **3. Private sector** • Transcorp Hilton • Beloxxi Group • Nigerian Breweries Plc • Flour Mills of Nigeria • Nestlé Nigeria • GB Tannery Limited • ZEC Industry • Cutix Plc • Tawada Limited • Transtell Ventures • Tummy Tummy Foods • Geoelis Cables Limited • BUS Industries Limited • S.M.D plastic • S.A Bagadawa

Source: Authors' own compilation, Infratec Environmental Technologies (2025) based on completed survey questionnaires (2025)

4.2 Relevant German solutions

Germany has developed several proven renewable heat technologies that can be integrated into Nigeria's industrial sector. The leading German heat solution technologies with the potential to address Nigeria's existing energy challenge are listed on the right.

Table 4 provides a strategic overview of German heat solution technologies, categorising them on the basis of their potential in Nigeria and the associated challenges by delineating immediate, emerging, and long-term strategic opportunities. Solar thermal systems, biomass boilers, and CHP offer immediate opportunities with high potential and lower challenges. Heat pumps and waste heat recovery (WHR) represent emerging opportunities with moderate potential and manageable challenges, Finally, long-term strategic investments represented by power-to-heat (P2H), hydrogen-based heating systems, and geothermal heat systems can offer base-load renewable power, albeit with high exploration and drilling costs requiring a long-term, high-risk investment strategy.

TABLE 4. German heat solutions categorised on the basis of potential in Nigeria

Technology	Description	Potential in Nigeria	Challenges
Solar thermal systems	Uses solar collectors to generate heat for industrial and residential applications.	Suitable for process heat in industries (food processing, textiles) and rural electrification.	High initial investment, need for large installation areas.
Biomass boilers	Utilises organic waste by converting it into heat and electricity.	Utilisation of agricultural residues for power and heat in agro-industries.	Fuel availability, logistics, and supply chain constraints.
CHP	Uses a single fuel source to generate electricity through a prime mover such as a gas turbine, steam turbine, or engine.	Generates electricity and useful heat for industrial and commercial applications.	High capital costs, unstable fuel supply, and grid and infrastructure limitations.
Heat pumps	Extracts heat from air, water, or ground for heating applications.	Useful for space heating and industrial low-temperature processes.	High capital cost, need for stable electricity supply.
Waste heat recovery (WHR)	Captures excess heat from industrial processes and repurposes it for heating needs.	Can improve efficiency in cement, steel, and food processing industries.	Technical complexity and retrofitting costs.
Power-to-heat (P2H)	Converts surplus electricity from renewables into heat for industrial processes.	Supports grid balancing and decarbonisation of heat-intensive industries.	Requires strong renewable energy infrastructure.
Hydrogen-based heating	Uses green hydrogen to produce heat for industrial applications.	Long-term solution for high-temperature industrial heat demand (e.g., cement, steel).	High production and storage costs, infrastructure gaps.
Geothermal heat systems	Utilises subsurface heat for direct use or power generation.	Could provide base-load renewable heat for industries and communities.	High exploration and drilling costs.

Source: Authors' own compilation, Infratec Environmental Technologies (2025) based on Nairametrics (2025)

4.3 German technologies in demand

This section presents a list of German renewable heat and process heat solutions relevant to Nigeria ranked according to the Technology Readiness Level.

Table 5 shows the varying Technology Readiness Levels of renewable heat technologies and Nigeria's adoption barriers; it presents a strategic roadmap for investment and policy direction in emerging markets like Nigeria.

This analysis underscores the need for tiered policy frameworks – from incentives and feed-in tariffs for high-readiness systems to research grants and pilot funding for low-readiness technologies. For investors, it signals a spectrum of opportunities: from near-term returns in mature technologies to strategic, future-proof investments in next-generation solutions. By aligning investment strategies with these readiness levels, stakeholders can drive impactful, profitable contributions to Nigeria's sustainable energy future.

TABLE 5. German heat energy solutions based on TRL

Heat energy technology	Estimated TRL rating	Readiness	Nigeria's adoption barriers
Solar thermal systems	8–9	High: Widely applicable and commercially viable. Strong demand for hot water and industrial heat makes this highly deployable.	Low to medium: High initial cost could be a barrier, but the high demand suggests a willingness to adopt if financing is available.
Biomass boilers	7–8	Medium: Particularly useful in agro-industries. Some projects exist, making this technology relatively mature.	Low to medium: Dependence on consistent biomass supply chains and potential logistical challenges in rural areas. Initial investment might be a factor.
CHP (combined heat and power)	6–7	Medium: Viable for localised, high-efficiency power and heat generation. Adoption is growing but limited by capital cost.	Low to medium: Dependence on a single fuel source to generate electricity. Initial investment cost might be a factor.
Heat pumps	6–7	Medium: Suitable for moderate climate heating. Adoption is early, but potential is strong in industrial sectors.	Medium: Potential initial cost, need for technical expertise in installation and maintenance. Awareness and understanding of the technology might be lower compared to more traditional systems.
Waste heat recovery (WHR)	6–7	Medium: Applicable in industries like cement and food processing. Moderate adoption, but technology is well understood.	Medium: Requires detailed process analysis and potentially significant upfront investment for implementation. Existing infrastructure and plant design might pose challenges.
Power-to-heat (P2H)	5–6	Emerging: The technology supports grid flexibility. Requires stable electricity access.	Medium to high: Reliance on a stable and affordable electricity supply, which can be a challenge in Nigeria. Grid infrastructure might need upgrades to handle significant P2H loads.
Geothermal heat systems	3–4	Low: Nigeria has potential but very limited implementation. Mostly conceptual or pilot-based.	High: High upfront investment and exploration risks. Requires specialised technical knowledge and infrastructure. Limited existing expertise and regulatory framework
Hydrogen-based heating	2–3	Low: Very early stage in Nigeria. Infrastructure, cost, and hydrogen production challenges exist.	Very high: Immature technology in the Nigerian context. High costs, lack of infrastructure, safety concerns, and limited technical expertise pose substantial hurdles.

Source: Authors' own compilation, Infratec Environmental Technologies (2025) based on Nairametrics (2025)

4.4 Analysis of the competitive and business environment

The key competitors to German renewable heat and process heat solutions in the Nigerian market are indicated on the right.

Table 6 provides an overview of the current competitors to German heat solution technologies in Nigeria across various product categories. It compares the presence of existing suppliers from countries such as China, India, Turkey, the USA, the UK, and Japan, as well as local Nigerian fabricators. Overall, while German heat technologies face strong competition in some segments – especially from China, India, and the USA – there remain strategic opportunities in this sector for the above products as well as in partnering with or strengthening local Nigerian fabricators. It also provides a framework for strategic business positioning and planning to deploy German solutions in Nigeria.

TABLE 6. The competitive and business environment for German solutions

Product	Existing competitors to German heat solutions						
	China	India	Turkey	Local fabricators/assemblers	USA	UK	Japan
Solar thermal systems	✓	✓	✓	✓	–	–	–
Biomass boilers	✓	✓	–	✓	–	✓	–
CHP (combined heat and power)	–	–	–	–	✓	✓	–
Heat pumps	✓		✓	✓	✓	✓	
Waste heat recovery (WHR)	–	–	–	–	✓	✓	–
Power-to-heat (P2H)	–	–	–	–	✓	✓	✓
Geothermal heat systems	–	–	–	–	✓	–	–

Source: Authors' own compilation, Infratec Environmental Technologies (2025) based on National Renewable Energy Action Plan (NREAP) (2015-2030)

4.4.1 Competitive factors

This section analyses the key competitive factors and German rating.

Table 7 presents an analysis of key market factors relevant to the competitiveness of German products in Nigeria. German products are noted for their high efficiency, which is a major strength, but they also come with a high initial cost, making them less accessible in a price-sensitive market. Additionally, after-sales support for German systems is currently limited, which poses challenges for maintenance and user confidence, whereas Chinese and Indian products typically benefit from moderate support through local dealers. Overall, German heat technologies offer superior performance, however their market competitiveness is constrained by higher cost, limited local support, and logistical hurdles.

TABLE 7. Key competitive factors

SN	Factor	Germany	China/India/others
1	Product efficiency	High	Medium
2	Initial cost	High	Low
3	After-sales support	Limited (currently)	Moderate (local dealers)
4	Product availability	Import-only (customs delays)	Stocked by local suppliers
5	Adaptability to local fuels	Medium	High

Source: Authors' own compilation, Infratec Environmental Technologies (2025) based on Karekezi, S. (2003)

4.4.2 SWOT analysis

This analysis was conducted systematically to evaluate the internal capabilities and limitations of venturing into the renewable heat and process heat solution sector in Nigeria, alongside the external factors that could influence success or pose challenges. It was carried out by meticulously identifying the unique strengths that German investors can leverage, the weaknesses they must address, the significant opportunities present in Nigeria's energy transition, and the potential threats that require mitigation.

German investors' competitive edge is undeniably superior technology and strong brand reputation. This allows them to target a premium segment that values efficiency and durability, likely specific industrial clients for whom uptime and long-term operational costs are paramount.

However, the analysis highlights a critical tension: high quality comes with high cost, which clashes with a market where cheaper alternatives are prevalent and financing is still maturing. To succeed, German investors cannot rely solely on technological superiority. They must actively mitigate the weaknesses and threats.

In essence, the investors' path to success lies in strategically deploying their technological strengths to maximise the opportunities while proactively addressing cost barriers and local market integration challenges, primarily through strong partnerships and a compelling value narrative.

TABLE 8. SWOT analysis

Strength	Weakness
• Technological leadership: German companies are renowned for high-quality engineering, efficiency, and reliability in renewable energy technologies. • Innovation: Strong R&D capabilities for advanced heating solutions. • Reputation: 'Made in Germany' carries a strong reputation for quality and durability, which is valued in industrial applications.	• High initial cost: German technologies often come with a higher upfront cost compared to solutions from China or even some local fabricators. • Lack of local presence and understanding. • Financing gap: Commercial financing for industrial renewable heat projects in Nigeria is still developing.
Opportunity	**Threat**
• Niche for high efficiency and reliability. • Partnerships: This can provide market access, local expertise, and support to overcome logistical hurdles. • Addressing specific industrial needs. • Advanced technologies.	• Competition from cheaper alternatives: Companies from China and India can often outcompete on price, even if their products might have lower efficiency or shorter lifespans.

Source: Authors' own compilation, Infratec Environmental Technologies (2025) based on Karekezi, S. (2003)

4.4.3 Business and environmental considerations

Shifting to renewable heat and process heat solutions can greatly reduce greenhouse gas emissions, which are a major contributor to climate change. By harnessing cleaner energy, adverse effects of pollution on the ecosystem and public health can be alleviated. However, investors should consider the potential environmental drawbacks associated with these technologies.

The lifecycle management of renewable heat and process heat technologies presents a critical opportunity for enhanced sustainability and strategic value. From the sourcing of raw materials for these cutting-edge solutions to the management of components at the culmination of their service life, a sophisticated circular economy approach is not merely beneficial, but essential. This becomes particularly relevant during the transition from conventional, often less sustainable, industrial and commercial heating systems to modern renewable heat and process heat solutions.

The strategic decommissioning of existing equipment offers a prime opportunity for resource recovery: implementing advanced practices for deconstruction, comprehensive material segregation, and high-value recycling of metals, plastics, and specialised components inherent in legacy boilers, furnaces, and associated infrastructure. By rigorously integrating reuse, refurbishment, and robust recycling programmes throughout the entire lifecycle – from the precision manufacturing of new renewable heat solutions to their seamless installation – investors can transcend mere compliance. This commitment not only amplifies the profound environmental benefits and long-term cost-effectiveness of renewable heat and process heat solutions, but also actively cultivates a forward-thinking culture of corporate responsibility and environmental stewardship, establishing a new benchmark for industrial sustainability.

5

Renewable Heat and Process Heat Solution Potentials In Nigeria

5.1 Renewable heat supply and process heat application

Nigeria faces significant challenges, including frequent power outages and ageing infrastructure, and demand far exceeds the available supply. These issues are exacerbated by a growing population and increased industrial activity. The blend of current challenges and proactive future policies illustrates Nigeria's complex energy landscape. By addressing infrastructure needs, embracing renewable energy, and fostering a regulatory environment conducive to investment, Nigeria aims to build a more reliable, efficient, and sustainable energy sector. The success of these plans will significantly depend on practical implementation, governance, and the capacity to adapt to technological advances and evolving market dynamics. Looking ahead, Nigeria's strategy emphasises sustainability, efficiency, and meeting increasing demand. Integrating renewable heat and process heat energy sources like solar and hydro will reduce dependency on fossil fuels and promote sustainability.

5.2 Renewable heat and process heat solution project development process

Project development processes for renewable heat and process heat solutions in Nigeria are represented below for a German heat solution product. The project development process captures the key activities to be carried out on the product, the stages involved, and the timeline.

Table 9 presents a roadmap for renewable heat and process heat solutions in Nigeria which underscores a methodical approach essential for successful implementation. This comprehensive framework will help to minimise risks, optimises efficiency, and ensures the sustainable delivery of renewable heat and process heat solutions, driving Nigeria's industrial and commercial sectors towards a cleaner, more energy-secure future.

TABLE 9. Project development process for a heat pump in the C&I sector

HEAT PUMP (C&I PROCESS HEAT) PROJECT STAGES & TIMELINE																								
SN	Activities	Estimated project timeline: 9 – 24 months																						
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	**Project inception & feasibility (2 - 6 months)**																							
1.1	Concept & needs assessment (0.5–1 month)																							
1.2	Pre-feasibility study (1–2 months)																							
1.3	Feasibility study (1.5–2 months)																							
2	**Project development & financing (3 - 8 months)**																							
2.1	Due diligence & legal structuring (1.5–3 months)																							
2.3	Permitting & approvals (1.5–3 months)																							
2.4	Financing & financial close (1–3 months)																							
3	**Project implementation & construction (3 - 8 months)**																							
3.1	Detailed engineering & design (1–2 months)																							
3.2	Procurement (1–3 months)																							
3.3	Construction & installation (1–3 months)																							
4	**Commissioning & operations (0.5 - 1 month for commissioning, ongoing)**																							
4.1	Commissioning & testing (0.5–1 month)																							
4.2	Operations & maintenance (O&M) (ongoing)																							

Source: Authors' own compilation, Infratec Environmental Technologies (2025) based on Scott Gillam, pfnexus (2023)

5.3 German renewable heat and process heat solutions – Case study

The following case study examines the adoption of German renewable heat and process heat solutions in Malawi as an illustration of their potential impact in Nigeria:

Case study: Supply & installation of PV hybrid and solar water heating systems in Malawi

Renewable energy solutions are playing a pivotal role in advancing energy security, efficiency, and environmental sustainability across Africa. The deployment of German-engineered renewable technologies has consistently proven effective across various sectors, delivering dependable and cost-efficient alternatives to conventional energy sources. A prime example of this is the 2021 commissioning of a turnkey 92 kWp photovoltaic (PV) hybrid system and a 6,000-litre solar water heating system in Malawi by SOLAR23, a leader in renewable solutions. The project, initiated in March 2020, was part of a broader energy efficiency initiative aimed at reducing fossil fuel dependence while ensuring reliable, clean energy supply.

Operational reliability is a key highlight of this installation. With minimal downtime, the system boasts an uptime rate of over 98% annually. Operation and maintenance (O&M) costs are estimated at just 1.5% of the capital expenditure per year, underscoring the long-term affordability of the system. The deployment has led to a drastic reduction in diesel generator usage and grid electricity consumption, generating substantial cost savings and reducing carbon emissions by approximately 120 metric tons annually. This has not only improved the facility's operational efficiency but also reinforced its commitment to environmental stewardship.

This successful implementation stands as a benchmark for similar initiatives across the continent. For countries like Nigeria – where rising energy demand and heavy fossil fuel reliance present major challenges – the Malawian case offers a practical and scalable model. Industries such as manufacturing, healthcare, hospitality, and agriculture in Nigeria can benefit immensely from adopting similar PV hybrid and solar thermal systems. The Malawi installation showcases the technical feasibility, economic viability, and environmental benefits of German renewable energy solutions, presenting a compelling case for broader adoption across Africa's emerging economies.

5.4 Major hurdles in the implementation of renewable heat and process heat projects in Nigeria

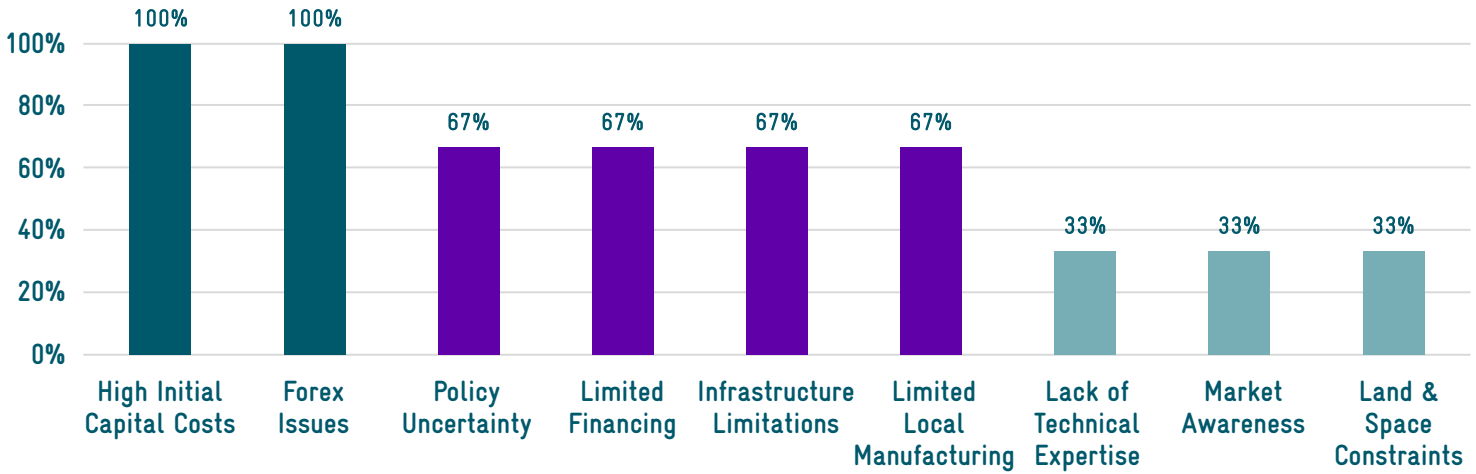
Implementing effective renewable heat and process heat solutions in Nigeria faces significant challenges, primarily stemming from unreliable electricity infrastructure, widespread poverty, and rapid, unplanned urbanisation. The inconsistent power supply hinders the consistent use of cooling appliances, while economic constraints limit access to energy-efficient technologies for a large portion of the population. Furthermore, the prevalence of poorly ventilated housing in densely populated urban areas exacerbates heat stress, and the influx of inefficient, second-hand cooling units further strains the already burdened power grid and contributes to environmental pollution. Compounding these issues is the need for more robust policy implementation regarding building codes and energy efficiency standards, as well as the need to increase public awareness of passive cooling methods.

Figure 11 presents a stark illustration of the hurdles facing the implementation of renewable heat solutions in Nigeria. The survey reveals that the most significant obstacles are high initial capital costs and forex issues, both registering a 100% impact.

These challenges underscore the financial barriers to adopting renewable technologies, exacerbated by the volatility of the Nigerian naira and the reliance on imported components, both of which are critical considerations for projects in Nigeria.

A substantial 67% of respondents identified policy uncertainty, limited financing, infrastructure limitations, and limited local manufacturing as major impediments. This highlights the need for a stable and predictable regulatory environment, coupled with innovative financing mechanisms to attract investment. The inadequacy of existing infrastructure and the lack of a robust local manufacturing base further compound the challenges, hindering the integration of renewable heat solutions into Nigeria's energy landscape, particularly in urban centres like Abuja where infrastructure development is crucial.

FIGURE 11. Key challenges in implementing renewable heat and process heat solutions



Source: Authors' own illustration, Infratec Environmental Technologies (2025) based on completed survey questionnaires (2025)

6

Market Entry Strategies, Risks, and Relevant Analysis

6.1 Market entry strategies

To maximise market opportunities, German investors should prioritise robust stakeholder engagement strategies. This can build a solid foundation for renewable heat and process heat solution projects in Nigeria. A collaborative approach of this nature not only enhances project feasibility, it also contributes to long-term success and community resilience. The most essential market entry strategies are detailed in Table 10.

This strategic framework is designed to significantly expedite the integration of renewable heat and process heat solutions within the Nigerian market by prioritising a strategic approach to the introduction of renewable heat and process heat solutions in Nigeria, thereby securing the enduring success and widespread adoption of these technologies across Nigeria.

TABLE 10. Market entry strategy

SN	Strategy	Rationale	Implementation	Product introduction
1	Strategic partnerships and joint ventures (JVs)	Local partners can help navigate bureaucratic hurdles, build trust, and mitigate political and economic risks	German investors should seek reputable Nigerian companies with experience and strong financial standing as partners.	JVs can be instrumental in adapting German products to local needs and conditions.
2	Licensing and technology transfer	This can foster local job creation and skills development.	This requires careful consideration of intellectual property protection.	This helps localise product offerings and potentially reduce costs, making the products more competitive in the Nigerian market.
3	Pilot projects and demonstrations:	This can help build confidence among potential clients and policymakers.	Collaborating with key stakeholders to implement pilot projects for specific applications.	Successful pilot projects provide tangible evidence of the product's benefits, facilitating broader adoption and market penetration.
4	Focus on niche markets and off-grid solutions	This creates strong demand for decentralised renewable energy solutions, including renewable heat for industrial processes.	German investors can target specific industries that heavily rely on diesel generators for their heat requirements.	Tailoring products to meet the specific energy demands and cost sensitivities of these niche markets is crucial.
5	Leveraging government policies and incentives	The Nigerian Government has expressed a strong commitment to renewable energy and has implemented various policies and incentives to attract investment.	Understanding and leveraging these can significantly improve market entry success.	Highlighting how German products align with and benefit from these government incentives can be a strong selling point.
6	Capacity building and training:	German companies can differentiate themselves by investing in local capacity building.	Offering specialised training programmes for Nigerian engineers, technicians, and local installers.	This not only supports product adoption but also builds long-term relationships and a sustainable local ecosystem for the technology.

Source: Authors' own compilation, Infratec Environmental Technologies (2025) based on International Finance Corporation (IFC) (2021))

6.2 Risk assessment and mitigation strategies

In the pursuit of sustainable development, renewable heat and heat process solutions offer immense potential for Nigeria's energy landscape. However, this sector is exposed to a range of risks that can hinder growth and implementation. Identifying and addressing these risks is crucial to building a resilient and scalable renewable heat energy sector in Nigeria. The various risk categories, potential impact, and probability of occurrence are highlighted in Table 11.

Table 11 presents a risk assessment across five categories (political, economic, operational, community, and financial) for a renewable heat project, detailing specific risks, their potential impacts (primarily project delays and increased costs), estimated probability of occurrence, and the percentage range of the project fund potentially impacted. High-impact and high-probability risks include corruption and bribery, inflation, lack of clear regulation, and land acquisition issues, which could significantly affect project timelines and budgets. Notably, 'high upfront costs' carries the highest potential financial impact, representing a 100% financing failure risk. The assessment provides a structured overview for prioritising risk mitigation strategies based on the likelihood and potential financial consequences. Effective management of these identified risks is paramount for the successful deployment of renewable energy solutions in Nigeria.

TABLE 11. Risk analysis

SN	Risk category	Specific risk	Potential impact	Probability/ occurrence	% of project fund impacted (estimated range)
1	Political risks	Policy/changes	Unfavourable regulatory changes, delays in approvals, increased taxes, project delays, or invalid project insurance.	0.3 (30%)	10–20%
		Corruption and bribery	Increased project costs, delays, and fines/penalties.	0.6 (60%)	15–25%
		Currency fluctuations	Increased project costs due to operational and exchange rate volatility.	0.4 (40%)	5–15%
2	Economic risks	Inflation	Increased project costs and reduced purchasing power.	0.6 (60%)	5–10%
		Economic downturn	Reduced government funding or donor aid, and/or asset devaluation.	0.2 (20%)	10–20%
3	Operational risks	Lack of clear regulation	Delays in project approvals, increased project investment or halted investment.	0.4 (40%)	20–30%
		Regulatory changes in laws	Reduced project profitability, increased project support.	0.3 (30%)	5–15%
		Environmental regulations	Increased project costs, project delays.	0.4 (40%)	5–15%
		Operational/ technical/agency	Project delays, technical issues, reduced reliability.	0.7 (70%)	10–20%

SN	Risk category	Specific risk	Potential impact	Probability/ occurrence	% of project fund impacted (estimated range)
4	Community risks	Social acceptance	Opposition to project leading to delays, increased costs, or social unrest affecting communities.	0.3 (30%)	10–20%
		Land acquisition issues	Unforeseen delays and increased compensation costs.	0.6 (60%)	10–20%
5	Financial risks	High upfront costs	Project delays Inability to secure financing.	0.4 (40%)	10–20% (delays) 100% (financing failure)
		Lack of skilled labour	Delay in project installation and reduced quality of work.	0.4 (40%)	5–15%
		Technology failure	Equipment failures, reduced performance, or increased maintenance costs.	0.2 (20%)	5–15%
		Supply chain disruptions	Delay in equipment supply, price increases, or lack of critical materials.	0.6 (60%)	10–20%

Source: Authors' own compilation, Infratec Environmental Technologies (2025) based on International Finance Corporation (IFC) (2021)

6.2.1 Sensitivity analysis

A sensitivity analysis was conducted for a renewable energy heat process investment serving 10 food and beverage factories over a 10-year period. It examined how changes in the selling price of heat and the operating expenditure (OPEX) impact the project's net present value (NPV) and internal rate of return (IRR) for further consideration. See Annex 2

Key findings

- **Base case:** With no changes to the initial estimates for selling price and OPEX, the project yields a negative NPV of USD -1,086,813 and a negative IRR of -3.80%. This suggests the project is not financially viable under the initial assumptions.
- **High price/low OPEX:** A positive scenario with a 20% increase in the selling price of heat and a 20% decrease in OPEX results in a significantly positive NPV of USD 1,057,387 and a highly attractive IRR of 16.20%. This highlights the strong potential profitability if favourable market conditions and efficient operations are achieved.
- **High price/high OPEX:** Even with a 20% increase in the selling price, if OPEX also increases by 20%, the NPV is still positive at USD 345,787, but the IRR drops to 7.60%. This underscores the importance of controlling operating costs to maximise returns, even with strong revenue.
- **Low price/low OPEX:** A negative scenario with a 20% decrease in the selling price and a 20% decrease in OPEX leads to a more negative NPV of USD -2,581,013 and a lower IRR of -16.40%. While lower OPEX partially mitigates the impact of lower revenue, the project remains financially unattractive.
- **Low price/high OPEX:** The most unfavourable scenario, with a 20% decrease in the selling price and a 20% increase in OPEX, results in the most negative NPV of USD -3,292,613 and the lowest IRR of -21.80%. This clearly demonstrates the detrimental effect of low revenue and high costs.

6.2.2 Regression analysis

An ordinary least squares (OLS) regression analysis was conducted on the sector analysis, and the results offer some insights relevant to this work. The statistically significant positive coefficient for 'output electricity' (0.000141 with a p-value of 0.0002) suggests that increased electricity output is associated with higher annual energy costs. This might imply that the current methods of electricity generation, heavily reliant on fossil fuels in Nigeria, become more expensive as production scales up. Conversely, the negative coefficient for 'renewable energy' (-5.38E-05 with a p-value of 0.6608), although not statistically significant at the conventional 5% level, indicates a potential inverse relationship between the proportion of renewable energy in the mix and overall energy costs. If this relationship were to become more pronounced and statistically significant with increased adoption of renewables, it could strongly support the economic viability of transitioning to renewable energy sources, including heat energy solutions, in Nigeria.

The high R-squared value (0.879669) indicates that the model explains a large portion of the variation in energy costs, making these relationships worth further exploration with a focus on heat energy technologies like solar thermal or sustainable biomass, which are particularly relevant for Nigeria's context. See Annex 3

7

Recommendations and Conclusion

7.1 Recommendations

Based on the key findings from these studies, the following recommendations are proffered for both the potential investors and Nigerian Government for consideration:

1. Strategic partnerships and local collaboration:

Navigating a new market like Nigeria requires local expertise, trust, and established networks. Collaboration mitigates risks and enhances market access. For potential investors, especially German investors, partnering with reputable local entities is crucial for understanding the nuances of the Nigerian business operating environment. This would require:

- Identifying and vetting potential local partners (businesses, financial institutions, research bodies, industrial associations) for potential partnership consideration.
- Establishing clear partnership agreements outlining roles, responsibilities, and benefits.
- Actively engaging with local communities and stakeholders to build trust and ensure project acceptance.
- Prioritising partners with strong ethical standards, and aligning with global best practices and established networks.

2. Thorough due diligence and risk assessment:

Understanding the regulatory landscape, financial risks (forex, policy uncertainties), and market dynamics is fundamental for informed investment decisions. German potential investors, known for their meticulous approach, should prioritise comprehensive risk assessment. This would require:

- Conducting in-depth market research to identify specific sectoral needs and challenges.
- Carefully assessing the regulatory landscape, financing options, and potential policy uncertainties.
- Analysing potential risks associated with foreign exchange fluctuations.
- Implementing robust risk mitigation strategies (e.g., long-term contracts, currency hedges, insurance).

3. Focus on high-demand and viable technologies for initial entry:

Prioritising technologies with existing demand and alignment with Nigeria's resources offers a quicker path to market entry and revenue generation. Solar thermal and biomass boilers & CHP fit this profile due to the needs of the agro-industrial sector and rural electrification. German investors can leverage their expertise in these areas. This would require:

- Focusing initial market entry efforts on solar thermal systems and biomass boilers & CHP.
- Developing tailored solutions for the agro-industrial sector and rural communities.
- Showcasing proven relevant case studies (especially from Germany and other African nations) to build confidence.

4. **Development of decentralised and off-grid solutions:**

Nigeria's grid instability creates a significant demand for reliable off-grid and decentralised energy solutions. This presents a strong opportunity for investors offering such technologies, particularly in solar thermal and biomass-based CHP for industrial parks and rural communities. This would require:

- Emphasising decentralised energy solutions like off-grid solar thermal and biomass CHP.
- Targeting key demographics like households (solar home systems), SMEs (distributed generation), and public institutions.
- Developing robust and reliable off-grid renewable heat systems.

5. **Innovative financing solutions and business models:**

Addressing the financing gap and high upfront costs is crucial for the wider adoption of renewable heat and process heat solutions. Innovative models can make these solutions more accessible to end-users. German investors can bring financial expertise and explore partnerships with both local and international development finance institutions. This would require:

- Developing innovative financing solutions and partnerships to address the funding deficit.
- Considering using models like ESCOs and leasing to reduce upfront costs.
- Investigating opportunities for blended finance and leveraging international climate finance mechanisms.
- Offering comprehensive solutions and services including financing options.

6. **Technology transfer and capacity building:**

Investing in local skills development ensures the long-term sustainability of projects and fosters a skilled workforce. For German investors, this demonstrates a commitment to Nigeria's development beyond just profit. This would require:

- Leveraging expertise and core technology to contribute to the development of the sector.
- Investing in training local partners and workforce for installation, operation, and maintenance.
- Facilitating technology transfer initiatives.

7. **Engagement with government and policy advocacy:**

A supportive policy environment is crucial for the growth of the renewable heat energy sector. Active engagement can help shape favourable regulations and access to potential incentives. This would require:

- Actively engaging with government agencies (e.g., NASENI, ECN) to provide feedback on policy frameworks.
- Advocating policies that support renewable heat adoption and a more supportive investment environment.
- Working closely with public authorities to align technology offerings with national energy policies and explore potential incentives or support mechanisms.

8. Long-term investment perspective:

Recognising the long-term growth potential of the Nigerian renewable energy market is essential for sustainable investment. This aligns with the typically longer-term focus of German investments. This would require:

- Adopting a long-term perspective, recognising the growth potential.
- Committing to building strong relationships with local stakeholders and establishing a sustainable market presence.

9. Highlighting energy efficiency and cost savings:

Emphasising the economic benefits of renewable heat technologies, such as reduced operational costs and energy efficiency gains, is a strong selling point for potential clients, especially in industrial applications. This would require:

- Highlighting the energy efficiency benefits of technologies like heat pumps and WHR.
- Emphasising the long-term cost savings associated with renewable heat solutions.
- Showcasing proven solutions and their economic viability.

10. Exploration of emerging and advanced technologies:

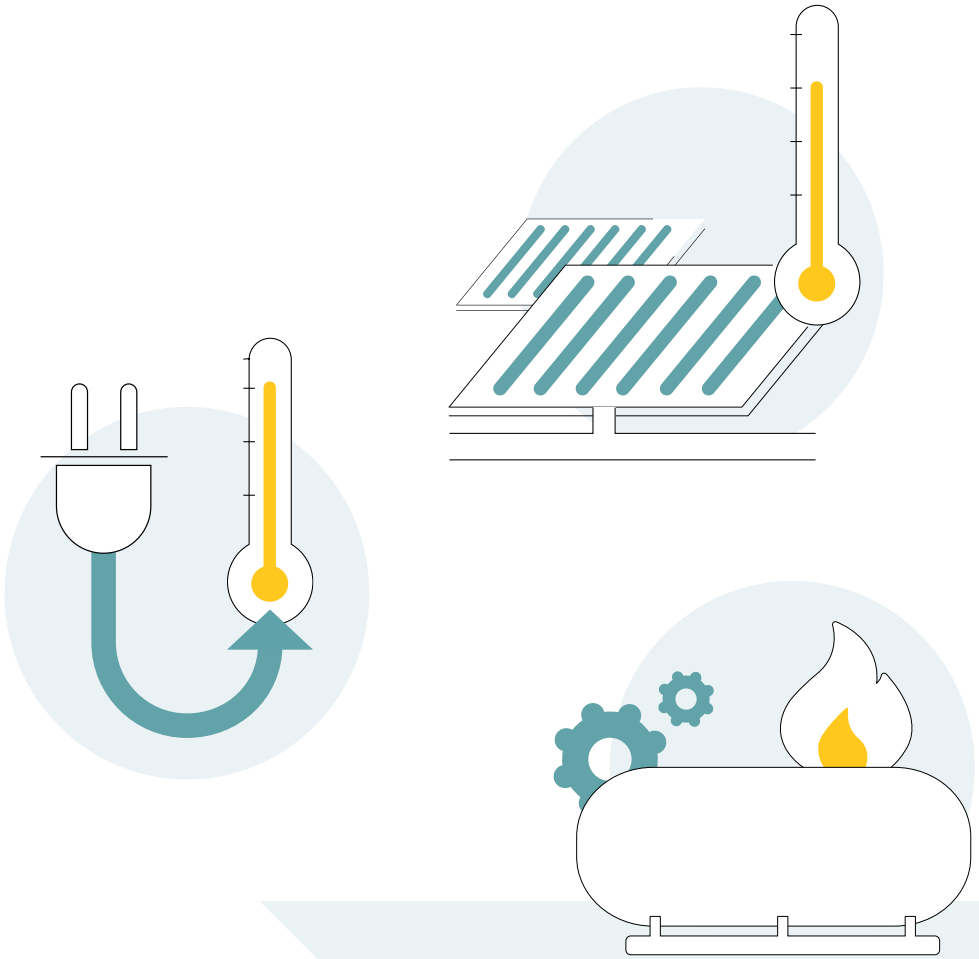
While immediate opportunities exist, keeping an eye on future trends and exploring pilot projects for advanced technologies can position investors for long-term growth. This would require:

- Monitoring the development of Nigeria's grid infrastructure.
- Considering heat pumps and waste heat recovery systems for industrial applications as the market evolves.
- Exploring pilot projects and technology transfer initiatives for power-to-heat, geothermal, and hydrogen-based heating.

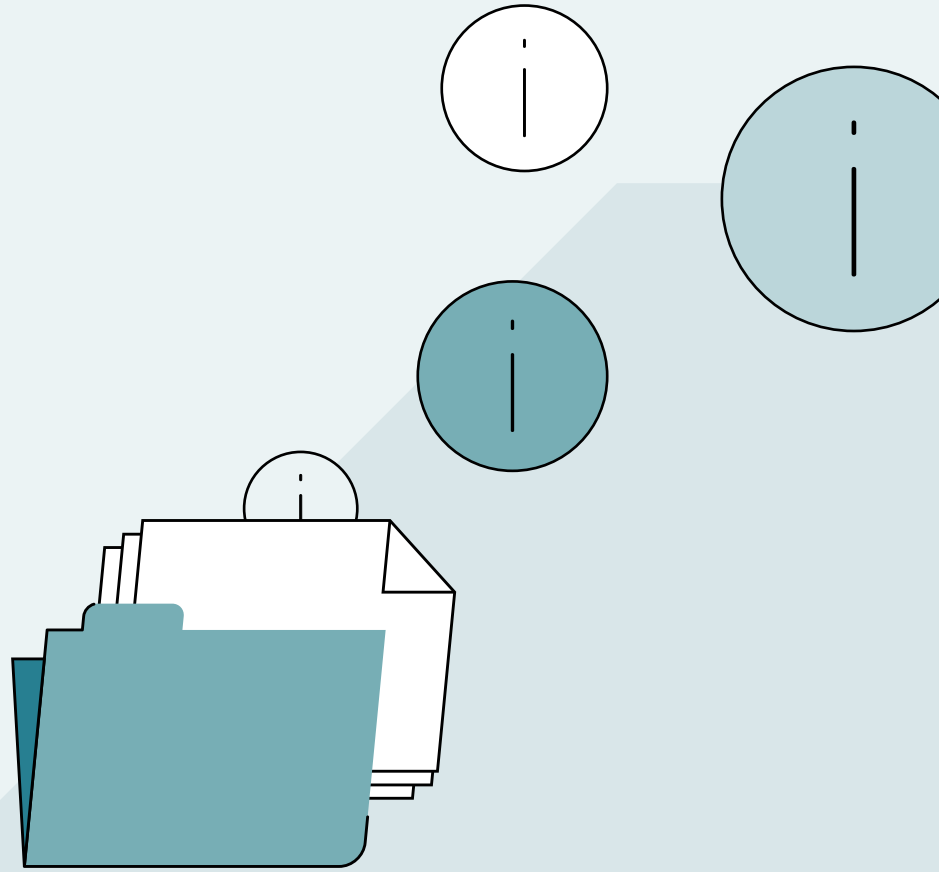
7.2 Conclusion

Nigeria's expanding renewable heat sector offers a strong investment proposition, especially for German firms. Abundant resources, improving policies, and rising demand for cleaner heating in a youthful, urbanising nation create fertile ground for innovation. Recent reforms point to better transparency and investment conditions, alongside a diversifying economy prioritising renewables and attracting global interest, positioning Nigeria as a prime market for German technology and finance.

To fully realise this potential, systematic implementation of key recommendations is vital. This includes strengthening institutional coordination, enhancing investment incentives, fostering capacity building, and promoting public-private partnerships. For potential German investors, active involvement through strategic partnerships, technology transfer, knowledge sharing, and collaboration not only promises significant returns but also aligns with their energy transition goals, contributing to sustainable development in a key African market where their expertise is highly valued and needed.



Annexes



Annex 1 Summary of Distributed Questionnaires

TABLE 12. Sectional Categorisation of Questionnaires

SN	Category	Key section
1	Financial institutions	• General information • Experience in energy and renewable energy financing • Financing process heat and renewable heat supply solutions • Policy and regulatory environment • Market outlook and investment potential
2	Public authorities	• General information • Research and sectoral insights
3	Private sector (factories utilising process heat technology)	• General information • Industry and market conditions • Investment climate and business environment • Technology and market readiness • Challenges and opportunities • Future plans and recommendations
4	Research institutions	• General information • Research and sectoral insights

Source: Authors' own compilation, Infratec Environmental Technologies (2025) based on completed survey questionnaires (2025)

TABLE 13. List of Completed Questionnaires

SN	Category	Organisation	Key focus
1	Financial institutions	World Bank	One of the largest development finance institutions in the world with a track record of supporting renewable energy deployment.
		Access Bank Nigeria	Offers dedicated financing for energy and manufacturing projects.
		Keystone Bank	Supports industrial businesses with funding for energy-efficient technologies.
		Bank of Industry (BoI)	Nigeria's largest development financing institution, supporting industrial projects.
2	Public authorities	National Agency for Science and Engineering Infrastructure (NASENI)	Develops engineering infrastructure and technology in Nigeria.
3	Factories utilising process heat technology	Beloxxi Group	A major manufacturer of biscuits and confectionery products utilising process heat.
		Nigerian Breweries Plc	Uses process heat in brewing and beverage production.
		Boskel Nigeria Limited	Uses process heat in manufacturing activities
		Nestlé Nigeria Limited	Integrates process heat in food and beverage manufacturing.
		Flour Mills of Nigeria	Employs process heat in food processing and flour milling.
		Geoelis Cables Limited	Employs process heat in the production of quality cable wires.
		Tummy Tummy Foods Industry	Uses process heat in processing flour to manufacture noodles.
		Transtell Ventures Nigeria Limited	Employs process heat in the production of edible vegetable oil.

SN	Category	Organisation	Key focus
3	Factories utilising process heat technology	Tawada Limited	Uses process heat to produce ink.
		Cutix Plc	Uses process heat to manufacture cable wire and related electrical products.
		ZEC Industry	Uses process heat in the recycling of materials.
		BUS Industries Limited	Employs process heat in rubber processing.
		S.M.D Plastic	Employs process heat in the processing and manufacture of plastic.
		S.A Bagadawa Poly Bag	Uses heat in processing hide and skin to make bags
		GB Tannery Limited	Uses heat in processing hide and skin to make leather.
4	Research institutions	Delta State University	Specialises in thermodynamics and heat transfer research related to process heat technologies.
		Federal University of Petroleum Resource	Research on biodigester for energy, off-grid petroleum.
		Bayero State University	Concentrated solar power for rice paddy parboiling and drying.

Source: Authors' own compilation, Infratec Environmental Technologies (2025) based on completed survey questionnaires (2025)

Annex 2 Financial model and sensitivity analysis

TABLE 14. 1 MW Solar Thermal Plant – CAPEX & OPEX breakdown (Nigeria, 2025)

Financial model								
Year	Revenue (USD)	OPEX (USD)	Depreciation (USD)	Interest (USD)	Profit before tax (USD)	Tax (USD)	Net profit after tax (USD)	Net cash flow (USD)
0	0	0	0	0	0	0	0	-3,000,000
1	275,000	60,000	149,750	378,000	-312,750	-93,825	-218,925	-2,620,925
2	288,750	61,800	149,750	346,500	-269,300	-80,790	-188,510	-2,309,435
3	303,188	63,654	149,750	315,000	-225,216	-67,565	-157,651	-1,932,086
4	318,347	65,564	149,750	283,500	-180,567	-54,170	-126,397	-1,488,483
5	334,264	67,531	149,750	252,000	-135,017	-40,505	-94,512	-972,995
6	350,978	69,557	149,750	220,500	-88,829	-26,649	-62,180	-385,175
7	368,527	71,644	149,750	189,000	-41,867	-12,560	-29,307	22,468
8	386,953	73,793	149,750	157,500	5,910	1,773	4,137	100,105
9	406,300	76,007	149,750	126,000	54,543	16,363	38,180	214,285
10	426,615	78,287	149,750	94,500	104,078	31,223	72,855	324,140

NPV (USD) -1,086,813
IRR -3.80%

Source: Authors' own compilation, Infratec Environmental Technologies (2025) based on mini-grid CAPEX and OPEX benchmark study (2024)

TABLE 15. Sensitivity analysis

Sensitivity analysis				
Scenario	Selling price change	OPEX change	NPV (USD)	IRR (%)
1. Base case	0%	0%	-1,086,813	-3.80%
2. High price/low OPEX	20%	-20%	1,057,387	16.20%
3. High price/high OPEX	20%	20%	345,787	7.60%
4. Low price/low OPEX	-20%	-20%	-2,581,013	-16.40%
5. Low price/high OPEX	-20%	20%	-3,292,613	-21.80%

Source: Authors' own compilation, Infratec Environmental Technologies (2025) based on mini-grid CAPEX and OPEX benchmark study (2024)

Annex 3 Regression analysis

TABLE 16. Regression analysis secondary data

Year	Energy cost (annual %)	Output (electricity) GWh	Renewable energy (GWh)	GDP growth rate (%)
2005	9.34	22,528	7,703	6.51
2006	9.34	22,049	6,213	6.03
2007	9.38	21,924	6,178	6.59
2008	10.01	20,143	5,677	6.76
2009	10.04	18,830	4,497	8.04
2010	10.4	24,887	6,325	8.01
2011	10.05	25,721	5,839	5.31
2012	10.06	27,303	5,639	4.23
2013	10.07	27,459	5,315	6.67
2014	11.34	30,610	5,338	6.31
2015	11.46	33,167	6,470	2.65
2016	12.14	36,533	8,202	-1.62
2017	12.16	32,239	7,796	0.81
2018	12.16	36,699	7,762	1.92
2019	12.2	36,464	8,514	2.21
2020	12.2	37,995	7,806	-1.79
2021	12.2	39,205	8,106	3.65
2022	12.33	38,008	9,397	3.25
2023	12.37	42,509	9,728	2.86

Source: CEIC's economic databases and Enerdata

TABLE 17. Regression analysis

Variable	Coefficient	Std. error	t-statistic	Prob.
GDP growth rate	-0.05715	0.056988	-1.002852	0.3318
Output electricity	0.000141	0.0000289	4.876177	0.0002
Renewable energy	-0.0000538	0.00012	-0.447599	0.6608
C (constant)	7.361136	0.945535	7.785158	0.0000
R-squared	0.879669	Mean depend-ent var	11.01316	-
Adjusted R-squared	0.855603	S.D. dependent var	1.186236	-
S.E. of regression	0.450766	Akaike info criterion	1.428926	-
Sum of squared residuals	3.047847	Schwarz cri-terion	1.627755	-
Log likeli-hood	-9.574799	Hannan-Quinn criterion	1.462576	-
F-statistic	36.55197	Durbin-Watson stat	1.282494	-
Prob (F-statistic)	0.0000	0.00E+00	-	-

Dependent variable: energy cost annual
Method: least squares
Date: 04/25/25
Time: 12:17
Sample: 2005 2023
Included observations: 19

Source: Authors' computation, Infratec Environmental Technologies (2025) based on E-views 12, 2025

Annex 4 C&I sector summary data from distributed questionnaires

TABLE 18. C&I sector summary data from distributed questionnaires

SN	Sector	Name	Electricity	Gas	Diesel	Biomass	Coal	Solar	CNG	Steam boilers	Annual energy exp. (NM)	% of OPEX	Staff	Years of operation	Heat technology	Heat level	Rank	Estimated heat demand
1	Food & beverage	Beloxxi Ltd	–	–		–	–	–		–	1,687,982,111	4	–	–	WHR	250	High	–
		Nestlé	–			–	–	–	–	–	1-5m monthly	–	250 +	–	–	100 - 400	Medium	10 - 50 GJ/MWh
		FZE Igomu	✓	–	–	–	–	–	–	–	5-10m monthly	–	250 +	–	WHR	100 - 400	Medium	50 - 100 GJ/MWh
		Transtell Ltd	–	–		–	–	–	–		–	20	59	16	Heat pumps, WHR	250	High	100 +
		Tummy Tummy Food	–	–	–		–	–	–	–	–	–	500	16	WHR	100	Low	10 - 50 GJ/MWh
2	Manufacturing (cable wire and plastic)	Cutix Ltd	–	–		–	–	–	–	–	529,341,00	–	296	42	Solar thermal, CNG, solar power	100 - 150	Medium	50 - 100 GJ/MWh
		S.M.D Plastic	✓	–	–	–	–	–	–	–	1-5m	–	50	–	–	100 +	Medium	10 GJ/MWh
		Geolis Ltd	–	–	–	–	–	–	–	–	300,000,000	–	200	40	Biomass boilers, WHR	100 - 150	Medium	50 - 100 GJ/MWh

SN	Sector	Name	Electricity	Gas	Diesel	Biomass	Coal	Solar	CNG	Steam boilers	Annual energy exp. (NM)	% of OPEX	Staff	Years of operation	Heat technology	Heat level	Rank	Estimated heat demand
3	Chemical & pharma	Tawada Ltd	–	1	–	–	–	–	–	–	1m annual	2	57	30	–	250	High	100 +
		ZEC Industry	–	–		–	–	–		–	–	45	120	8	CNG	100 – 250	Medium	–
4	Brewery & distillery	Nigerian Breweries plc	–	1		–	–	–	–	–	10m +	–	250 +	–	–	100 – 400	Medium	50 – 100 GJ/MWh
5	Rubber processing	BUS Industries	✓	–		–	–	–	–	–	10m +	–	250 +	–	–	100 – 400	High	100 +
6	Leather & bag (processing)	GB Tannery	–	–		–	–	–	–	–	–	–	200	28	CHP	100 – 250	Medium	–
		S.A Bagadawa	✓	–		–	–	–	–	–	1m – 5m +	–	50 – 250	–	–	100 +	Medium	10 – 50 GJ/MWh

Source: Authors' own compilation, Infratec Environmental Technologies (2025) based on completed survey questionnaires (2025)

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