Industrial process heat: Opportunity for sustainable retrofitting Kenya

Stakeholders engaged

17 **Project developers, potential clients and other private actors**

Ariya Finergy, Logstor, EA Energy, Eenovators, Endustrial, Negawatt, Global Supply Solutions, Sanivation, Renetech, Eastern Produce Kenya Mbogo Valley Tea, East African Power, Kuresoi, James Finlay Kenya, Equator Bottlers/Coca-Cola Bottlers Africa, MG Sustainable Engineering, Kenya Tea Development Agency

4 **Associations**

Kenya Association of Manufacturers, Kenya Green Building Society, Kenya Flower Council, Solar Heat Europe

4 **Development agencies and third sector**

GIZ, Rainforest Alliance, WWF Kenya, Private Financing Advisory Network

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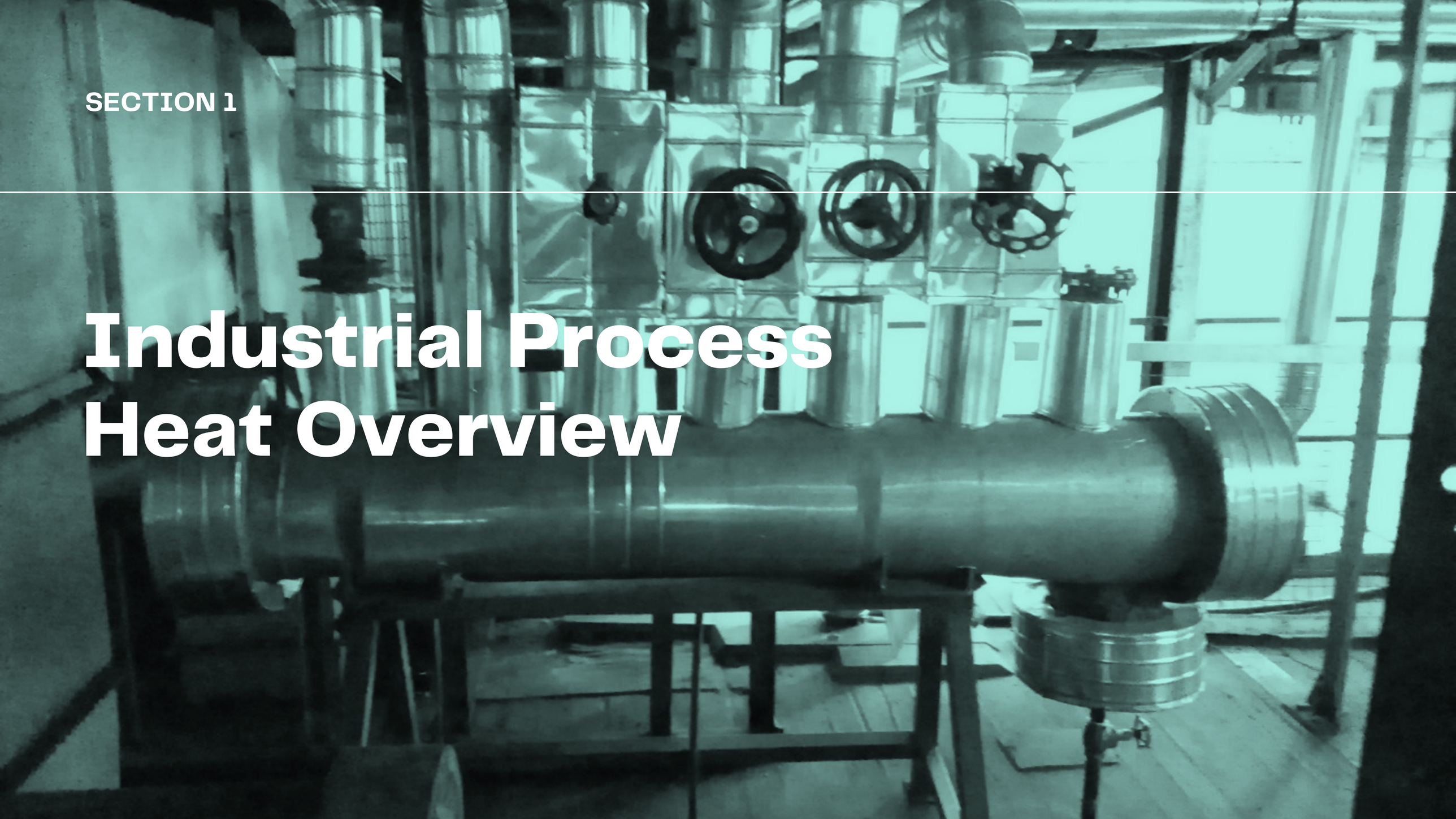
Industrial Process Heat Overview



Introduction

Process heating or industrial process heat is a general term that refers to heat transfer, distribution and utilisation techniques used in industrial production. Process heating is vital to nearly all manufacturing (industrial) processes, supplying heat needed to produce basic materials and commodities., used for a diverse range of activities including distillation, evaporation, drying, extraction, curing, heat treating, melting etc.

There are a range of drivers for businesses selecting the energy source and heat delivery medium for processes – temperature, fuel availability, throughput, product requirements, initial cost and operational safety among others. Each option may provide retrofitting challenges and energy saving opportunities.

Warm Air

Warm air is generally used for the lower temperature ranges of process heating, such as for drying activities or to remove water or other solvents from a product.

Hot Water

Unless pressurized, low temperature hot water's range and utility for industrial processes is limited.

Thermal Oil

Thermal oil is usually used where temperatures higher than those which can be readily attained using water are required.

Steam

Steam is the most widespread process heat delivery medium. Most systems deployed in the market are considered or confirmed to be steam.

Temperature bands and uses

Understanding the typical temperature ranges of heat process is critical for optimising design and futureproofing of systems. As heat distribution systems are optimised for specific temperature ranges, conducting energy efficiency first helps to ensure the system works at a higher efficiency for longer; energy efficiency interventions could possibly change the temperature levels of streams entering processes. Furthermore, thermal generation from renewable energy, is more effective at lower temperatures, therefore best practice would be to install energy efficiency measures, including high efficiency/low loss pipework, prior to retrofitting generation technologies.

Sector	Operation	Temperature range (°C)
Food	Drying Washing Pasteurising Boiling Sterilising Heat Treatment Cooking	40–200 60–90 60–80 95–105 110–140 40–60 70–120
Beverages	Washing Sterilising Pasteurising	60–80 60–90 60–70
Paper	Cooking and Drying Boiler feed water Bleaching	110–200 60–90 130–150
Metal Surface Treatment	Treatment, electro-plating, etc.	30–80
Bricks and Blocks	Curing	60–140
Textiles	Bleaching Colouring Drying Washing Fixing Pressing	40–100 40–130 60–90 50–100 160–180 80–100
Chemicals and pharma	Biochemical reactions Distillation Sterilisation Cleaning	20–60 100–200 100–200 60–90

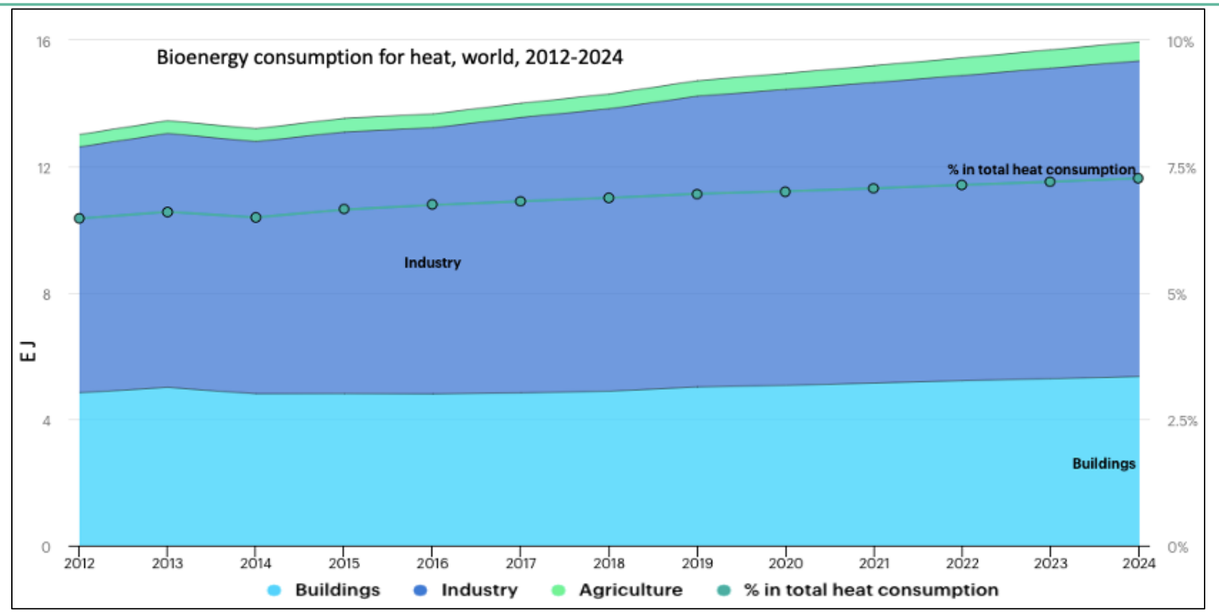
SECTION 2

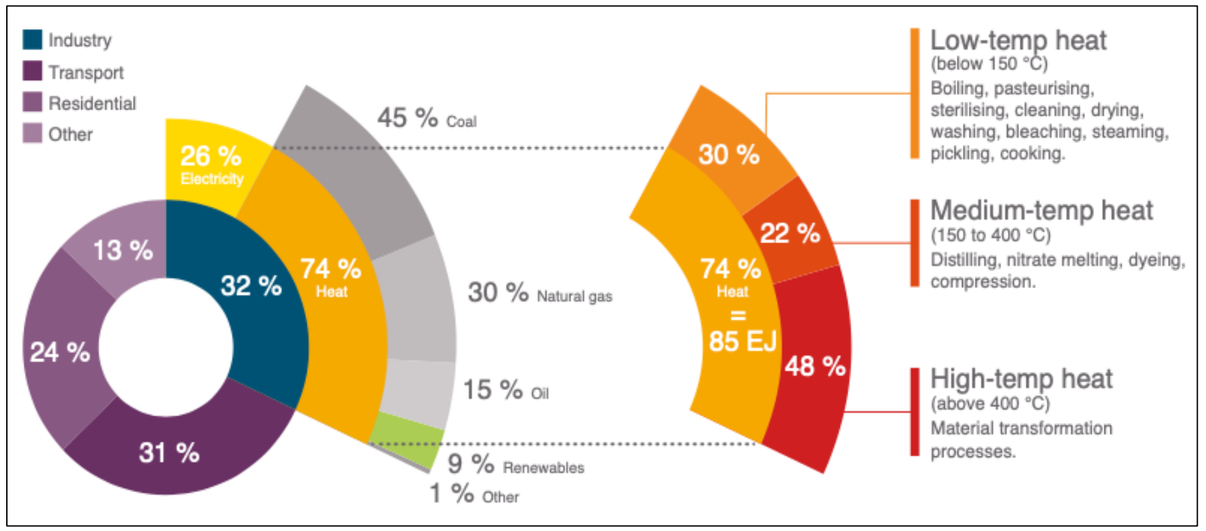
Opportunity

Global heat demand

Globally, heat remains the largest energy end-use behind transport (29%) and electricity (21%). It accounted for half of global final energy consumption in 2018, and around 50% of total heat produced was used for industrial processes.[1]

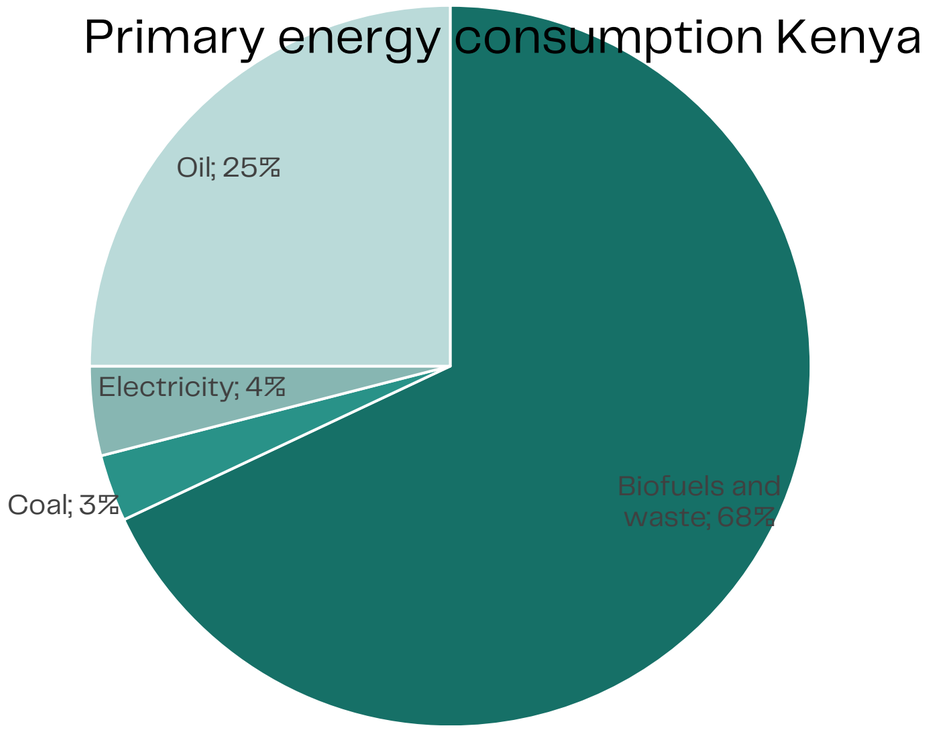
The heat demand for operating low and medium temperature represents a valuable market niche within the industrial sector. This deficit is more prominent in most emerging and developing economies, where heat demand continues to increase driven by economic and population growth.





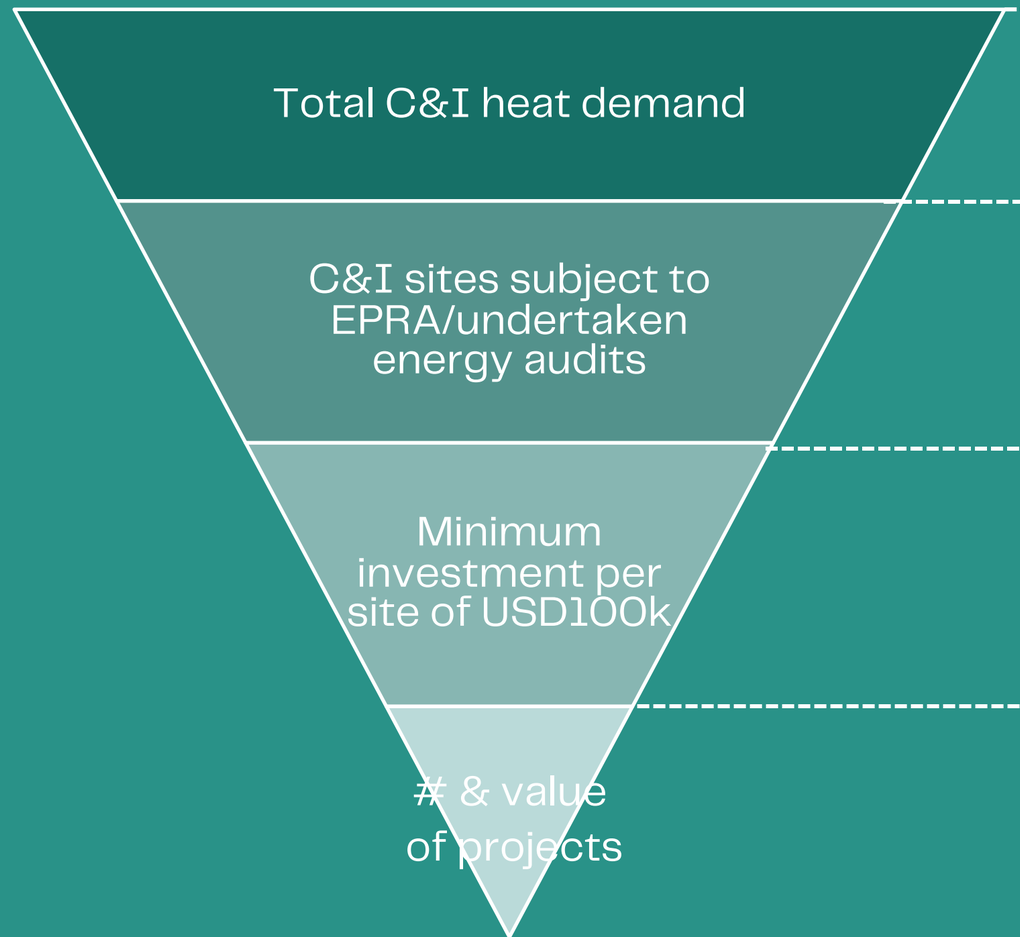
Kenya heat demand

Total energy consumption in Kenya was 335 TWh in 2019[2]. Kenya's energy mix is strongly dominated by traditional biomass, which accounts for more than two-thirds (228 TWh) of the country's final energy consumption. The high traditional biomass consumption is primarily due to household use of wood fuel for cooking and then commercial and industrial (C&I) use. Unfortunately, the Energy Petroleum Regulatory Authority (EPRA) the energy industry regulator, do not hold a centralised database of thermal energy consumption by C&I sector[3], unlike with electricity. However commercial and industrial sector is estimated to account for 38% of the countries' bioenergy demand amounting to 87 TWh per year. Solar water heating, parabolic solar collectors and other forms of renewable direct heat generation are additional to this.



Total addressable market in Kenya

Market sizing methodology relies on latest data available and application of specific filters to estimate the total addressable market



Total thermal demand from C&I facilities in Kenya

- Excludes clean cooking, thermal power generation, solar/open air drying, and renewable heat fuel supply (i.e., sustainable biomass, parabolic solar collectors)

Energy audits of C&I facilities currently undertaken every 3 years

- Draft Energy Regulations 2020 plan to increase this to every 4 years, to allow time for implementation of recommendations. Engaging customers that don't have an energy usage or demand baseline is not a viable market development approach

Larger commitments than existing C&I PV

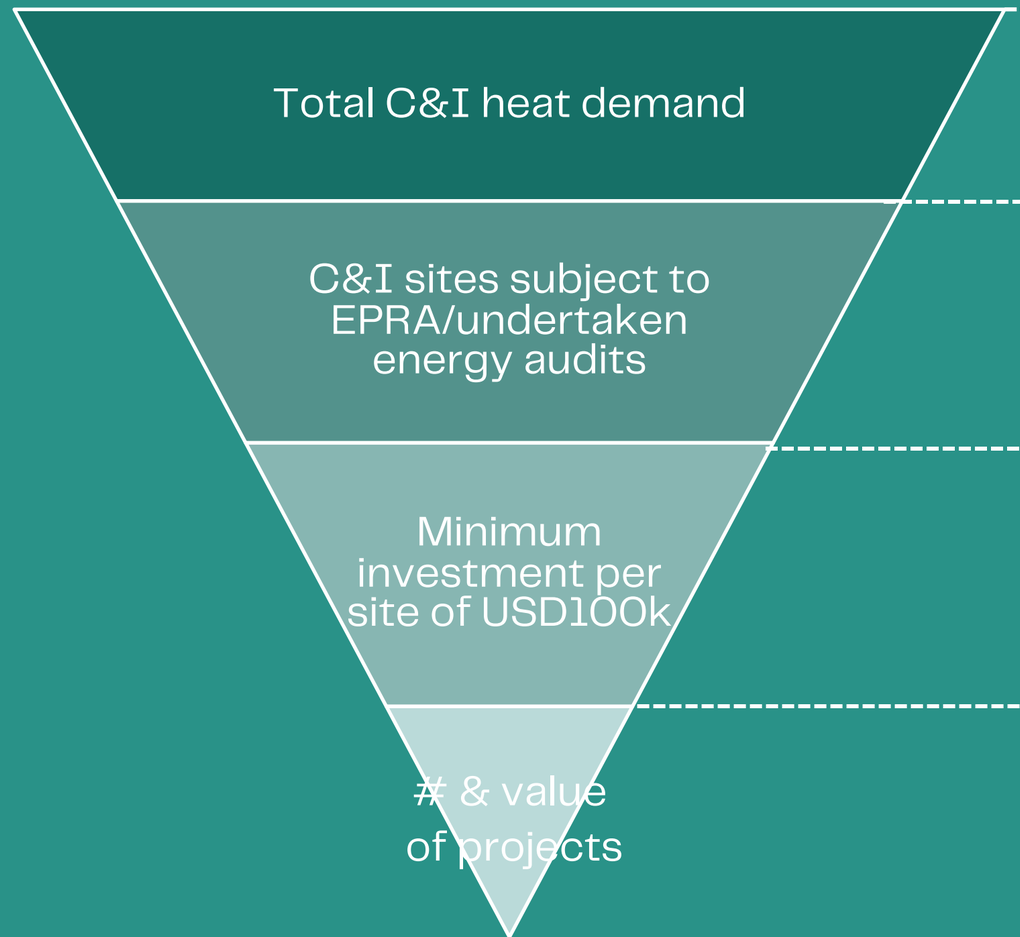
- Developers/providers require commitment/'skin-in-the-game' to justify the equipment and intellectual capital/resource investment necessary to confidently invest in new product/service ranges

Total addressable market estimate

- A base case scenario based on the above filters is presented

Total addressable market in Kenya

The total addressable market for demand-side sustainable heat retrofits is estimated at **USD5.45m per year** as a base-case scenario.



Total thermal demand from C&I facilities in Kenya

- Demand is estimated at 86.85 TWh utilising traditional biomass/wood fuel
- The market for improving or transition to a renewable heat supply is not assessed in detail, but KTDA demand alone for eucalyptus is 4.1 TWh, costing approximately USD70m per year.

1,313 facilities completed compliant energy audits

- During the first 6 years of implementation of the Energy Management Regulations 2012.
- Of these, 43% (564) implemented the recommendations listed and were compliant.
- 90% (508) of these recommended measures for thermal heat network efficiency.

Larger commitments than existing C&I PV

- All energy audits reviewed had thermal network recommendations above USD100k. However, this is a very small-sample. A request to EPRA for detailed breakdown is pending, so for now 43%, of the 508 (218), in line with those implementing the recommendations is used.

Total addressable market estimate

- On a cycle of every 3-4 years 218 sites should be investing in large-scale sustainable retrofitting of their heat networks.
- Equates to USD21.8m throughout the next auditing period and USD5.45m a year
- Represents a fraction of the potential market for renewable C&I heat supply yet is a necessary or best-practice precursor to a renewable transition; 'lean then green'.

Featured market segments

Most commercial and industrial enterprises in Kenya utilise a heat distribution network. This includes cement, steel, pulp and paper, horticulture, chemicals and agri-food. 90% of the 1300+ companies that have undertaken energy audits within the ERC/EPRA Energy Management Regulations have recommended heat generation and distribution measures and up to 95% of the energy demand derives from heat and stream supply[3]. The manufacturing sector which encompasses these market segments accounts for ~10% of GDP[4].

Tea

KTDA demand for 70 factories is 1MT of wood fuel ≈ 4.1 TWh of heat demand per year[5]. Equivalent to half the electrical energy demand in Kenya.

Manufacturing

Includes concrete, steel, plastics, chemicals, pharma and other food and beverage covering dairy processing, soft and alcoholic beverage processing, brewing, distilling and other agri-processing.

Hospitality and retail

The hospitality industry encompassing hotels, restaurants, bars and shopping malls, is a key industry in Kenya employing around 9 million people, directly and indirectly in Kenya contributing 10% of GBP in Nairobi, Mombasa and Kwale counties[6].

Market segment: Tea processing

The tea sector in Kenya is the highest employer in the private sector and the world's largest tea exporter, represents a substantial portion of the country's rural and export income1. The production of tea requires energy in both electrical and thermal form; however, up to 90 % of the industry's expenditures are made up of thermal energy2. 96.9 % of the total thermal energy used by Kenya's tea factories are being generated from eucalyptus wood, and the remaining 3.1 % comes from fuel oil3. Using wood fuel such as eucalyptus trees and other fast-growing trees, have high water absorption and affect the water table of the ground (+40% higher consumption than indigenous trees).

Key actors

KTDA: 4.1 TWh of heat demand p.a. across 70 tea factories, equivalent to approximately half of the electricity consumption in Kenya. 4This represents the largest potential market in Kenya.

Energy audit and management firms: 100s of audits are carried out every year by specialised audit firms. Partnering with these firms provides direct access to clients and detailed information for proposal development

Agencies, association and development actors: GIZ and DANIDA have been supporting the industry with energy efficiency retrofits and renewables integration for many years, along with KAM and more recently the Rainforest Alliance.

Case study – Tea processing

The facility is the leading manufacturer of instant and aroma tea which are exported as finished product. The process consumes both electrical and thermal energy for running machine and process heating, the facility annual energy consumption is as follows: electrical energy **8,014,981 kWh** thermal (Diesel) **379,822 kWh** and Thermal (Wood) **138,542,360** kWh (~95% heat). The objective of the audit conducted was to study the energy usage/quality in the facility in addition to identifying Energy Conservation Measures (ECMs).

Energy Conservation Measure (ECM)	Estimated Annual Energy Savings (kWh)	Estimated Annual GHG Reduction (tCO_2e)	Simple ROI (years)	IRR (%)
Real Time Energy Monitoring: Installing Real Time Energy Monitoring Equipment	240,449	88	0.9	103%
ISO 50001: Training of managers and equipment acquisition	160,300	59	1.9	54%
Voltage Optimization and Stabilization: Installation of four voltage optimizers and stabilizers	721,348	265	2.6	57%
Lighting systems: Replacement of current lighting system with LEDs	132,745	49	2	64%
Compressor air systems: Compressor retrofitting and leaks fixing	224,640	83	2.7	50%
Compressed air leaks: Fixing of compressed air leaks in the plant	44,928	16.5	0.4	267%
Steam traps: Replacing steam traps in the process house and plant	1,154,520	450	3.5	40%
Steam leaks: Fixing all the steam leaks in steam lines	230,904	90	0.9	87%

Key insights

While installing high-efficiency pipework is not directly highlighted (likely as it is not readily available in the market) replacing steam traps and fixing leaks is. Steam traps are automatic energy loss devices and a repeated point of failure. Replacing the steam traps accounted for >40% of the total energy savings proposed and 50% of the CO_2e reductions. Designing or retrofitting an industrial heating system to reduce condensate generation and steam trap need, is a more effective energy conservation measure than regular steam trap replacement and maintenance.

Case study: FMCG manufacturing

The company located off the main Nairobi – Mombasa road in Nairobi is a manufacturer of edible oils, soaps, detergents, baking powder, sulphuric acid and noodles. The objective of the audit conducted was to study the energy usage/quality in the facility in addition to identifying Energy Conservation Measures (ECMs). From combustion, to steam distribution, lighting, compressed air, the range of measures and detail is substantial and at a CAPEX of ~$4m represents a considerable investment for many industrial facilities. A summary of the measures is given below.

Energy Conservation Measure (ECM)	Estimated Annual Energy Savings (kWh)	Estimated Annual GHG Reduction (tCO_2e)	Simple ROI (years)	IRR (%)
Lighting: LED replacement of 1,315 fixtures	363,672	120	2.4	32%
Compressed air: Fix leaks	9,699	3.2	0.6	154%
Compressed Air: Centralized control of compressors	62,500	20.6	1.6	62%
Waste heat recovery	1,680,000	525.8	2	48%
Replacement of steam traps/valves	468,650	146.6	0.65	135%
Replacing Aluminium fans with FRP blades	24,269	8	2	49%
Installation of centrifugal compressors in chillers	134,500	44	1.4	69%
VFDs for Cooling Towers	84,993	28	2	49%

Key insights

Again, the two measures with the largest impact on energy performance improvement is on the heat network. Additionally, there is a small proportion of coal used in the combustion process, providing considerable opportunity for GHG reductions. The heat network is aging and in need of an overhaul.

Case study – Steel fabrication

Located in Mombasa the facility produces galvanized corrugated iron Sheets. The process involves galvanizing of the cold rolled steel sheets with Zinc using a continuous hot dip wet flux galvanizing process, and then shearing to the desired length and corrugating to the standard profile. The annual energy consumption of the facility is **840,249 kWh** of KPLC electrical energy, **38,425 kWh** of diesel generated electricity, and **5,801,930 kWh** thermal energy which sums up to a grand total of **6,680,594 kWh**.

Energy Conservation Measure (ECM)	Estimated Annual Energy Savings (kWh)	Estimated Annual GHG Reduction (tCO_2e)	Simple ROI (years)	IRR (%)
Energy Management System (EMS): Behavioral changes, training and energy awareness	16,805	6.2	1.2	77%
Real Time Energy Monitoring: Installing Real Time Energy Monitoring Equipment	42,012	15.5	1.8	48%
Voltage Optimization: Lowering the Stabilized voltage to 220 V	67,220	24.8	4	25%
Lighting systems: Replacement of Security Lights with LEDs	8,165	3	2.5	61%
High Efficiency Motors: Replace the Standard Efficiency with High Efficiency Motors	29,181	10.8	3.3	38%
Variable Frequency Drives –Retrofitting: VFDs for Compressor, Air drier and Hydraulic system motors	66,612	24.6	2.8	32%
AC Best Practices: Replace Split Units With a VRF	13,104	4.8	4.1	20%
Steam traps: Replacing the 5 steam traps with nozzle type steam traps	81,666	181.8	1.8	117%
Steam Leaks Correction: Rectify all the Steam and Condensate Leak Points	26,375	58	1.6	139%
Insulation of Steam Lines: Steam Lines and Condensate Return Lines Insulation	55610	123.1	1.1	91%

Key insights

Again, steam lines and steam traps appear to be key areas of for improvement, energy conservation and GHG mitigation, accounting for 40% of the potential energy savings, and 80% of the GHG reduction potential. The ECMs are basic and not long-term solutions. High efficiency pipework, would provide solutions to all three without the need for maintenance or replacement within a relatively short time scale (<5 years).

The 17 Sustainable Development Goals

Heat network retrofits and SDGs

15 LIFE ON LAND

3 GOOD HEALTH AND WELL-BEING

Reducing wood-fuel demand

The majority of Kenya's GHG emissions under the Nationally Determined Contributions result from the agriculture and land use, land-use change and forestry (LULUCF) sectors, due to the high reliance on non-indigenous, non-renewable wood fuel., with additional degradation of the water table and air quality. Reducing the demand for wood-fuel is one of Kenya's most effective GHG mitigation measures.

7 AFFORDABLE AND CLEAN ENERGY

13 CLIMATE ACTION

Clean energy enabler

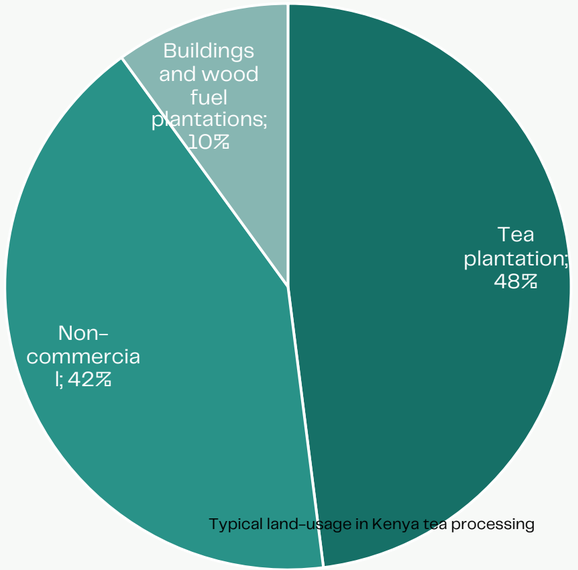
Best practice shows going lean is necessary precursor to going green. Renewables, especially non-combustion renewables such as solar thermal and parabolic solar collectors operate more effectively when delivering lower temperatures. Improving the efficiency, in particular reducing distribution losses is fundamental to increasing the share of renewables within C&I heating systems.

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

12 RESPONSIBLE CONSUMPTION AND PRODUCTION

Futureproofing and improving OpEx

Energy efficiency is the cheapest fuel source, creates skilled jobs and improves the economics of commercial operations.
Additionally, all the impacts are enablers to access carbon finance; once verified a long-term passive form income resulting from the retrofits.



Typical land-usage in Kenya tea processing

SECTION 3

Enabling Environment

Regulatory environment

Key authorities and legislation

Energy, Petroleum Regulatory Authority (EPRA)

The Energy Act 2019

Climate Change Act 2016

The Energy (Energy Management) Regulations, 2012

The Draft Energy (Energy Management) Regulations, 2020

The Energy (Appliances' Energy Performance and Labelling) Regulations 2016

The Energy Act 2019 gives EPRA the mandate to spearhead energy efficiency in the country. EPRA undertakes this duty via various tools which include development and enforcement of regulations, assistance in development of standards, codes, rules and guidelines, capacity building, technical support to state and non-state agencies and awareness creation to the public.

The Energy (Energy Management) Regulations 2012 and Draft Energy Management Regulations 2020 are two regulatory tools used to encourage and enforce improvements in industrial energy efficiency (i.e. demand side enabling). To achieve the ends of improving energy efficiency in designated facilities, EPRA licenses energy auditors and energy audit firms. The qualifications for this are stipulated in the Energy Management Regulations.

For suppliers of industrial scale energy efficiency equipment, there is a lack of direct incentives, whether reduced duties, tax incentives for supplying energy efficient equipment and the Energy Regulations 2016 does not encompass large scale industrial equipment. Furthermore, VAT for off-grid solar products was reintroduced with the Finance Bill 2020.

The Energy Management Regulations, 2012

Require that all commercial buildings, industrial and institutional facilities consuming more than 180,000 kWh (or 640,000 MJ) of energy to:

1. Formulate an energy management policy;
2. Appoint an energy officer;
3. Maintain production, energy and water consumption data for at least five years tabulated on monthly basis;
4. Conduct an energy audit every three years;
5. Implement energy audit recommendations to achieve at least 50% of the recommended energy savings;
6. Formulate an energy efficiency implementation plan showing how to implement the recommendations of the energy audit;
7. Submit energy efficiency implementation progress report to the Energy Regulatory Commission after every six months showing the projects implemented and savings achieved.

All the documents and reports listed under the Energy Management Regulations; the energy policy, the energy audit report, the energy efficiency implementation report and the energy efficiency implementation progress report, must be sent to the Energy Regulatory Commission for approval to comply. Organisations and/or persons failing to comply with the basic requirements; i.e. undertaking and submitting a compliant energy audit may be subject to a penalty of up to Sh1 million, one-year imprisonment or both.

Key insights

Audit quality and validity has continually been questioned since the first audits in 2015. Two auditors independently highlighted that often Investment Grade Audits (IGAs) undertaken under the Energy Management Regulations are rarely an IGA (albeit not their own) . Customers typically at the beginning of the enforcement saw these regulations as a compliance tool only and not an opportunity to reduce costs and improve margins. In many cases, the customer has requested an IGA to be written on the cover, paid for a general audit with significantly reduced measures and limited methodology, therefore reducing their perceived cost burden (ERC regs state 50% of the measures need to be implemented). The regulatory authority have limited resources to ensure compliance. Trusting the auditor and report is fundamental and CBE paying for the IGA may be the only option.

A well-executed IGA is a risk management tool, identifying the obstacles that might prevent the saving being realised. An IGA should indicate downtime of equipment and facilities needed to retrofit. In facilities with significant shift work or with 24/7 operations such as hospitals, knowing this detail is critical. The reports do not mention this. The authority, recently published a reflection document, highlighting areas of improvement for auditors, industrial and the regulators (source).

The Draft Energy Management Regulations, 2020

Key changes:

Energy Service Companies (ESCO)
The draft regulations will see the introduction of accredited ESCOs. ESCOs are defined as companies 'engaged in the business of undertaking energy audits and the development, design, financing, and building of energy conservation projects and whose compensation is directly linked to actual energy savings'. This may include companies such as Ariya Finergy.

The draft regulations propose the licencing of ESCOs which will required to seek accreditation before operating or continuing to operate.

The ESCO will be required to have an accredited category energy auditor in their employment. Once ESCOs are accredited they will have the authority to conduct energy audits of medium and high energy users and to develop, design, finance and build or implement energy conservation projects.

ESCOs will be required to enter into written contracts with their customers. The draft regulations specify the terms that must be contained in these contracts. The contracts must contain amongst other things the following:

a) Scope of the work: Setting of energy measurement baseline; energy baseline period; measurement and verification protocol to be applied (ow to measure energy and financial savings); and target savings

b) Mode of payment: Whether profits sharing and profit formula or payment from savings (state percentage for ESCO and Client) and payment period (how long will the ESCO earn from the project).

The energy service contracts must within 30 days be submitted to the EPRA to check for compliance. EPRA shall review the contracts and revert back to the ESCO and the client on any reservations.

The Draft Energy Management Regulations, 2020 cont.

Requirement for Designated Facilities to Appoint Energy Managers
The draft regulations propose making it a requirement for every owner of designated facilities, that is industrial, commercial and institutional facilities with an annual energy consumption of more than 180,000 KWh that are required to undertake an energy audit, to designate an accredited energy manager (previously energy officer). The failure to designate an energy manager will be an offence under the proposed regulations.

The energy manager's responsibility will be dedicated to ensuring the promotion of energy efficiency within the facility and the pursuance of energy conservation programmes.

Conduct of Energy Audits
The draft regulations propose the increase of the interval for the conduct of energy audits from once in every 3 years to once in every 4 years. The reason for the change in the interval is to allow owners of designated facilities more time for implementation of their energy savings plans.

The audits will have to be conducted by accredited energy auditors, energy audit firms or energy service companies and is required to comply with the Kenya standard KS ISO 50002.

Energy Savings Certificates and potential carbon/energy trading market?

Section 191 of the Energy Act, 2019 creates a scheme for the trading of energy savings certificates, enforced by The Draft Regulations. Facilities that consume less energy than the prescribed standards and norms can be issued with an energy savings certificate.

The certificate can be traded with those facilities that have a higher energy consumption than the prescribed standards and norms to enable them to be compliant.

In the draft regulations, designated facilities may apply for and be issued with one of two energy savings certificates.

- A White Certificate – if the energy performance indictor is better than the published best indicator for the sector.
- A Green Certificate – if the energy performance indictor meets the published allowable benchmark for the sector.

The certificates will also have a number of tradeable credits which will be determined from the annual energy saved from implementation of energy saving measures.

Investment incentives

Capital Allowances

Investment Deduction allowances deducted against profits and therefore tax, are permitted at varying rates (on a straight-line basis) for certain assets Starting at 50% in first year. However, no differentiation or specificity for energy efficiency/performance related products is provided.

Industrial Building Allowance

Hotels, educational facilities and industrial buildings including for refurbishments are eligible for similar deductions to the Investment Deduction.

Key insights

The primary reason to invest in commercial and industrial (C&I) energy performance whether electrical or thermal is for financial reasons. C&I solar in Kenya has seen the demand and install base grow rapidly, primarily due to the relatively high cost (compared with neighbouring countries) of grid derived electricity. The moratorium on logging in public and community forests, does not directly affect the price of wood for tea merchants, as most of the eucalyptus plantations are on private land. Additional levers, beyond the Energy Management Regulations, for heat and energy efficiency at the C&I scale are lacking.

Logistics, tariffs and duties

Tariffs and duties – need HS codes

SECTION 4

Finance

Carbon finance

The voluntary carbon market has come under justified scrutiny and skepticism and has been somewhat dormant over the last decade, with prices for verified emission reductions (VERs) well below USD10 for much of the period. However, in the first 8 months of 2021, prices increased by 60% driven by corporate net-zero ambition and growing interest in carbon markets to achieve Paris climate goals. It has the potential to reduce upfront implementation costs for developers and clients, by providing a long-term passive revenue stream, with the possibility to be traded as a future, upon contract signing.

However, securing verification and then the ability to acquire and trade these credit typically takes 2 years. Furthermore, retrospectively applying credits to existing projects is unlikely. Undertaking the exercise for a large portfolio (50+) of retrofits will be necessary too.

To support the identifying the potential to secure carbon credits, a summary of the potentially applicable frameworks and methodologies for retrofitting heating solutions is provided.

Gold Standard

Reduced emissions from cooking and heating – technologies and practices to displace decentralized thermal energy consumption (TPDDTEC).

Clean Development Mechanism

AMS-II.F: Energy efficiency and fuel switching measures for agricultural facilities and activities

AMS-II.G: Energy efficiency measures in thermal applications of non-renewable biomass

AMS-III.AM: Fossil fuel switch in a cogeneration/trigeneration system

AMS-III.AN: Fossil fuel switch in existing manufacturing industries

Verified Carbon Standard

VM0018: Energy Efficiency and Solid Waste Diversion Activities within a Sustainable Community

VM0025: Campus Clean Energy and Energy Efficiency (Presently US only)

Concessional Finance

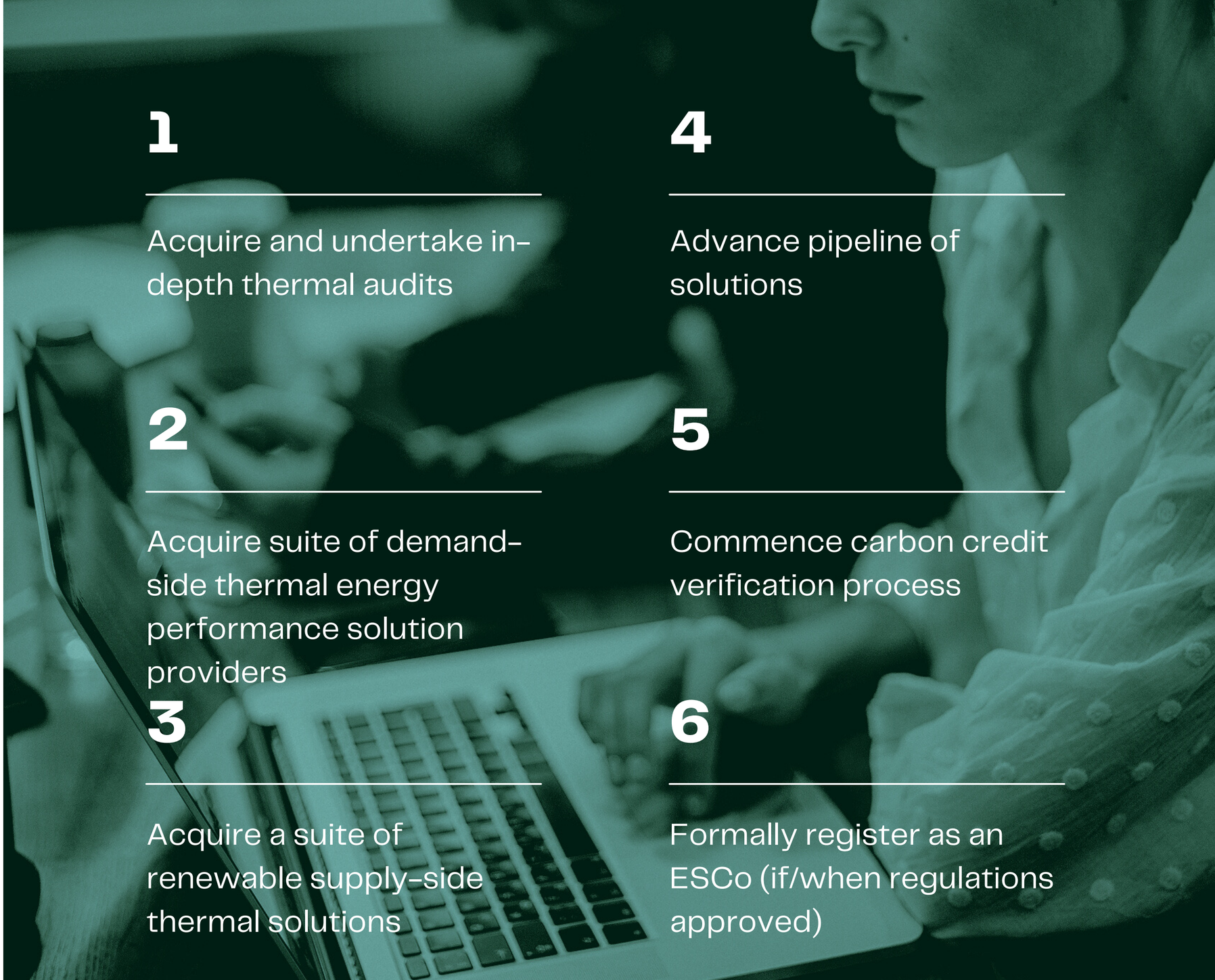
Next Steps

Gathering information from and engaging current and potential clients, is fundamental.

Securing an appropriate supply of demand and supply side solutions for heat performance. Pipework retrofits and controls systems, as opposed to stream trap maintenance and replacement programmes, would be more sensible on the demand side, while more sustainable biomass and renewable heat are available within market.

Developing carbon finance projects has a very large lead time, but can provide a significant windfall at scale.

Lastly, to ensure the continued licence to operate, register as an ESCo within Kenya will be necessary.



1

Acquire and undertake in-depth thermal audits

2

Acquire suite of demand-side thermal energy performance solution providers

3

Acquire a suite of renewable supply-side thermal solutions

4

Advance pipeline of solutions

5

Commence carbon credit verification process

6

Formally register as an ESCo (if/when regulations approved)