Completion Report

Greening Tea Factories in Kenya: using Absolicon Solar Collectors in Tea Process,

Kenya, NCF7, C7-0129

Grantee: Absolicon Solar Collector AB

Local Partner(s): WWF Kenya & Tealand Estate

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30/9/2024	Person responsible (Signature)
joakim@absolicon.com +46-705850059	JOAKIM BYSTRÖM CEO

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1. EXECUTIVE SUMMARY

The tea industry holds significant importance for Kenya. In 2022, tea was the country's foremost export product, positioning Kenya as the world's second-largest tea exporter. Kenya has about 200,000 hectares under tea, producing more than 400,000 tons of tea annually, directly supporting about 560,000 employees and their dependents.

However, drying the tea leaves is an energy intense process, requiring large amounts of heat and steam. The steam is produced in large steam boilers burning firewood. The firewood used to come from natural forests, but most tea factories today get the firewood from eucalyptus plantations.

The large area used for firewood production in eucalyptus plantations result in high virtual water consumption and greenhouse gas (GHG) emissions. As most tea factories lack energy efficient technologies this also results in substantial costs, reducing the cost competitiveness to Asian tea producers. The high production costs are comprising incomes for tea-pickers and small-holder farmers, who depend on tea for their livelihoods.

Since 90% of all energy consumption in a tea factory comes from heat and steam supplied from eucalyptus (electricity accounts for only 10%), the focus of this project is on heat production and consumption.

To substitute eucalyptus firewood, the project has introduced combining energy saving activities with solar thermal technology. Parabolic Trough Collectors (PTC) or "solar concentrators" produces steam up to 160°C that can replace firewood. The PTC technology is new in East Africa, and it is necessary to pilot the technique.

The project “Greening Tea Factories in Kenya” has a long-term ambition to find business concepts and innovative financing methods that would result in large scale introduction of energy saving measurements and appropriate solar thermal technology for heating in the tea industry.

The three partners in the project are bringing their specific expertise:

- **Absolicon**, a stock listed small innovation company with experience in decarbonising industry by applying concentrating solar thermal. Absolicon work in partnership with the consultant Stefan Jonsson at Glofin, an expert on innovating financing solutions and leasing.

- **Tealand** is a local engineering company and supplier of technical solutions to the tea industry with workshop in Kericho who have introduced the idea to the tea factories.

- **WWF Kenya** is an NGO with long experience in running climate projects in Kenya, and with a specific interest in energy saving, solar thermal and to make the tea industry less depending on eucalyptus monoculture.

Together with the cooperative KTDA that runs 66 tea factories in Kenya and other private tea factories, the project has a wide range of knowledge and experience. The project has provided us with valuable learning experiences, achieving notable success across its three key milestones. These milestones were:

1. **Raising Energy Efficiency Awareness and Capacity:** This milestone focused on increasing awareness and capacity for energy efficiency within the tea industry. In the project, three tea factories did energy audits and then implemented a ranged of identified activities (improving the efficiency of the boiler, changing inefficient electric motors, and installing energy efficient lighting). 64% of the planned energy efficiency activities were implemented with an average payback time of 7,5 months.

2. **Adoption of Solar Thermal and Energy-Efficient Measures:** This milestone involved the adoption and implementation of solar thermal technologies alongside other energy-efficient measures in tea factories. The work has been delayed by import problems, not foreseen in the planning. The solar collectors are at the tea factory, but critical components are still waiting delivery. KTDA has committed to finish the installation with pro-bono help from Absolicon after the end of the project. However, even as the pilot has not been put in operation, the process has resulted in a substantially increase interest in solar thermal in the Kenyan tea industry.

3. **Development of Business Concepts from Energy Savings and Solar Thermal Use:** The final milestone concentrated on leveraging the results from energy savings and solar thermal implementation to develop a business model that would continue the work after the end of the project. After developing three business concepts, one of the concepts has resulted in a multistakeholder partnership to offer industries in the region vetted energy solutions that come with financing solutions with the tea factories, WWF and UNIDO, ODA agencies like SIDA and regional banks. The “Industrial Cleantech Program”, as described in the business plan, aims to arrange financing tools developed in the project to upscale energy savings and solar thermal installations in tea factories. The multi-stakeholder group working, led by UNIDO and Glofin, are working to implement the program in 2024.

Despite the delay in installing and evaluating the parabolic trough collectors (PTC), now set for installation Q2 2024, the project has achieved many of its anticipated outcomes. The delay has not hindered the significant progress in other areas.

The outcome of milestone 3 “Industrial Cleantech program” has the potential to significantly benefit Kenya's tea industry by facilitating energy efficiency and solar thermal installations. The success of this concept is underpinned by the development of the 'Green Leasing' financial model, which reduces the cost of financing for tea industries to implement solar collectors and energy-saving activities.

In the project, even as the risks were identified, they were not easy to solve. Import regulations differ from the demands for CE-mark used in Europe, and this delayed the solar thermal part of the project.

All solar thermal component has by March 2024 finally arrived in Kenya, and an agreement has been reached with Absolicon, Tealand, and KTDA to continue the project beyond NDF funding, ensuring the installation of the solar field in Q2 2024.

Energy saving activities has long been proposed to improve the efficiency of the Kenyan tea industry. The project has used innovative business concepts to mobilise a multi-stakeholder group with the resources necessary to hopefully at last create a program with lasting impact on Kenya's tea factories energy consumption, with detailed description of planned activities presented in addendums to this report.

2. ACHIEVEMENT OF RESULTS

2.1 Achievement of outcomes and outputs

Expected outcomes and outputs	Indicator(s):	Achievement of outcomes and outputs:
Outcome 1: Tea factories have increased capacity on energy efficiency and are prioritizing implementation of energy efficiency measures	Indicator 1.1 Number of factories to have participated in energy efficiency capacity building and energy audits.	*Partly achieved: 3 (8)* *Three factories subjected to energy audits and have conducted energy saving activities. Two of the factories have been capacity strengthened on energy efficiency*
Output 1.1: Capacity built on energy efficiency, eucalyptus cost & challenges and emissions reductions potential	Indicator 1.1.1 Capacity building on energy efficiency. Training of staff members and workers of tea factories in energy efficiency measurements	*Achieved: 24 (20)* *A formal training was conducted in early March 2021 and attracted 24 participants, including 4 women and 20 men.*
Output 1.2: Tea factories have well-developed energy efficiency plans with energy assessment of the energy consumption in the tea factory before and after the activities.	Indicator 1.2.1 Tea factory baseline established, and energy plan(s) developed.	*Partly achieved: 3 (8)* *Three factories undertook baseline assessment and conducted energy efficiency audits. See report 'A2. Greening tea factories by energy audit and energy savings' for further details.*
Outcome 2: Adoption and installation of Solar PTC technology and other energy efficient measures by tea factories results in reduction of GHG emissions, energy cost savings.	N/A	*N/A*
Output 2.1 Solar PTC projects are planned, produced and shipped from Sweden.	Indicator 2.1.1 Solar PTC produced and shipped from Sweden	*Achieved: 198 m2 (396 m2)* *NCF agreed to reduce this target with the project team, and the indicator has successfully been met with the 198 m2 that was shipped to the Chelal tea factory.*
Output 2.2 Energy efficient measures and PTC are adopted by the tea factories based on recommendations from previous output.	Indicator 2.2.1: Installation of pilot installations of PCT	*Not achieved.* *Installation planned to Q2 2024 in accordance with discussions with NCF and a partner agreement signed 28/9 2023.*
	Indicator 2.2.2 Number of recommended activities adopted.	*Achieved: 64% (50%)* *64% present of the recommended activities were implemented by tea factories. See report 'A2. Greening tea factories by energy audit and energy savings'.*
Outcome 3: There's increased awareness of solar PTC technology within Kenya's industrial and financial sector and at least 2 additional companies is interested in testing the technology	Indicator 3.1 CO2 reduction during the duration of the project	*Achieved: 650 ton (300 ton)* *See report A2. Greening tea factories by energy audit and energy savings*

	Indicator 3.2 Number of green business concepts tested	*Achieved: 3 (3)* *The target was meet with development of three concepts that are detailed in the report, 'A1. Three green business concepts and financial tools'.*
Output 3.1: Kenya's industrial sector is sensitized and is adopting use of solar collector technology.	Indicator 3.1.1 Number of multi-stakeholder partnerships developed	*Achieved: 1 (1)* *Achieved through the creation of the "Industrial Cleantech program" detailed in this report.*
	Indicator 3.1.2 Program document for financial tools	*Achieved: 1 (1)* *The target was meet with development of three concepts that are detailed in the report, 'A1. Three green business concepts and financial tools'.*
	Indicator 3.1.3 Meetings (pcs) to find financing methods	*Achieved: 10 (10)* *Meetings were held ongoingly with stakeholders culminating with the final seminar held on 28 September 2023.*
3.2: Development and presentation of project impact assessment report	Indicator 3.2.1 Report from the end-term evaluation on project impact and operational excellence.	*Partially achieved: 1 (1)* *This completion report contains an end-term evaluation of the project as it was implemented. The matter related to 'operational excellence' can only be assessed once the installation is in place at the Chelal tea factory.*
	Indicator 3.2.2 Impact report and business plan	*Achieved: 1 (1)* *See separate document 'A3. Impact report and business plan' for further details.*

2.2 Deviations from the planned outputs and activities

Regarding Indicator 1.1 only three tea factories instead of eight participated in the energy audit activity. However, all of those three then continued by implementing the proposed action. 17 out of 22 energy saving actions were implemented in these three tea factories (64%).

Activity 2.2.1 was only partial finished – solar collectors has been shipped to Kenya, and the installation has started with the foundation work ready and the thermal storage tank designed. However, the installations of the solar collectors have not taken place. This is partly because of shipping issues for the pump and fan system from Sweden. All components are now in Kenya.

As discussed with NCF, a complementary agreement has been signed by the partners to install the solar collectors after the end of the project. The installation is planned to be ready in Q2 2024.

Activity 3.2.2 Distribution and presentation of the impact plan did not happen in the project as it was produced in the very end. However, the results and content

described in the document was used in the activities creating the multi-stakeholder partnership and on the final seminar. In the continued work with the business concepts, the report is an important tool.

2.3 Achievement of NCF indicators

Due to the nature of the project being a pilot installation for evaluation purposes, and the current progress, no significant and verifiable progress towards NCF core indicators has been achieved.

The delay in the project makes it premature to see a big impact of the project. If the resulting business concept Industrial Cleantech Program (ICTP) is starting according to plan, it will be a substantial impact according to NCF core indicator definitions.

NCF core indicator	Results (quantitative)			Clarifications/Means of verification
Number of beneficiaries reached	women		0	N/A
	men		0	
	total		0	
Number of people with increased resilience to climate change	women		0	N/A
	men		0	
	total		0	
Number of people with improved livelihoods	women		0	N/A
	men		0	
	total		0	
New decent jobs created	full-time	women	0	N/A
		men	0	
		total	0	
	part-time	women	0	
		men	0	
		total	0	
	seaso-nal	women	0	
		men	0	
		total	0	

3. CLIMATE CHANGE

The project had a clear idea to reduce CO2 emissions from the burning of eucalyptus and save on the use of electricity in the tea factories. Calculations gave the amount 300 ton at project inception.

However, the energy audit on the three tea factories found many potential activities and investments with short payback that reduced the CO2 emission. Average payback time for the activities were 7,5 months.

One important part of the project was to show how to reduce the burning of eucalyptus firewood. As each hectare of tea plantation produces 8 tons of green leaves which when dried produces 2 tons of tea. In the process, 10 ton of fuelwood (mainly sourced from eucalyptus) is used. Average land produce 20 tons of eucalyptus fuelwood per year, so every four hectare of tea plantation require one hectare of eucalyptus plantation.

However, eucalyptus plantations 43% more water than natural forest, with the deep roots drawing out a lot of ground water and nutrients. This, in combination with the competition to other plants (allelopathic) is dramatically reducing biodiversity and lay dry wetlands.

In the project, the Chelal tea factory installed an air preheater for one of their boilers. The analysis from the energy audit predicts that the investment (with 14,8 month payback) saves 604 ton of fire wood every year, corresponding 30 hectares of eucalyptus plantation.

The energy saving found were bigger than expected, and the tea factories has completed more activities than expected. The calculated CO2 saving is 650 ton even as the installation of solar collector field was delayed and did not contribute.

As examples, the most efficient activity for energy saving was in the Chelal tea factory. In addition to the air preheater mentioned above, the tea factory also replaced faulty open bucket steam traps and thermal insulation and had 2,5 years payback time. For the Litein tea factory, servicing of all other steam traps and installing thermal insulation saved 18,5 ton of CO2.

The shortest payback time in the tea factories were establishment of energy plans, fixing leaking steam pipes and installation of energy efficient lighting.

4. DEVELOPMENT IMPACTS AND CROSS-CUTTING ISSUES

Apart from the CO2 effect of the project, the measures implemented at the three tea factories resulted in savings of 283 546 kWh of electricity, about 750 m3 of firewood, and 12 531 386 KES, indicating the large potential a scale up of the project would have.

On cross-cutting issues, this project has had a narrow and limited scope on energy audit, energy production with solar thermal & energy saving, and business concepts. The main outcome is how awareness and technical solution can reduce cost, energy consumption and CO2 emissions in the tea factories and the cross-cutting issues has not been studied.

In the planning of the project, there was discussion about to include analysis of the potential impact of reduction of burning of eucalyptus firewood. Today, large forest areas around the tea factories have cut down and replaced with monoculture eucalyptus. Reducing the dependence on burning firewood would free large areas for alternative use, but also effect the livelihood of the people now working cutting down and transport the logs. This aspect has not been considered in the project.

The project's parts in Kenya have mainly been conducted under the supervision of WWF according to all rules and regulations, and no labour right or inequality aspects has been seen during the project. The part of the project that has been conducted in Sweden, project management and production of solar collector, has been done according to Swedish best practice, and according to all rules and regulations.

5. ASSESSMENT OF THE RESULTS AND IMPACTS OF THE PROJECT

5.1 Relevance

Alignment with Beneficiaries' Needs and Project Objectives

The project's main objective of reducing energy consumption and cost in tea factories aligns closely with the needs of the beneficiaries – the tea factories themselves. By focusing on energy-saving measures and solar thermal technology, the project addresses a significant cost factor in tea production, thereby enhancing the competitiveness and profitability of these factories. The achieved outcomes, such as the short payback period averaging 7.5 months for implemented energy-saving activities, demonstrate a direct response to the immediate needs of the tea industry.

Country's Needs and National Strategies

Kenya's reliance on the tea industry as a key economic sector makes the project's objectives highly relevant to the country's broader economic strategies. The project's focus on reducing energy intensity and cost directly supports the national priority of maintaining a competitive tea industry amid rising global competition, supporting a number of important country policy work:

- **Kenya Vision 2030**: As the country's long-term development blueprint aiming to transform Kenya into a newly industrializing, middle-income country, Vision 2030 identifies energy efficiency and sustainable resource management as crucial for industrial competitiveness. The project supports the vision's economic pillar by fostering an energy-efficient tea industry, which is integral to the agricultural sector and Kenya's economic development. Specifically, it could provide input to the Agriculture Land Use Master Plan. The Master plan will enable efforts targeted at efficient utilisation of all forms of land.

- **The Big Four Agenda**: Introduced by President Uhuru Kenyatta, the Big Four Agenda focuses on manufacturing, affordable housing, universal healthcare, and food security. By reducing energy costs and promoting renewable energy in the tea sector, the project contributes to the manufacturing pillar, ensuring that the tea industry remains robust and sustainable. Reduced requirement of land for eucalyptus plantations could provide land for food production thereby supporting food security through increased agricultural productivity.

- **Energy Act 2019**: This act emphasizes the importance of energy efficiency and renewable energy as key components of Kenya's energy policy framework. It provides a legal foundation for initiatives aimed at reducing energy consumption and promoting the use of clean energy sources within industries. The project's focus on solar thermal energy and energy-saving measures aligns with the act's

objectives, setting a precedent for renewable energy adoption in the tea industry and beyond.

- **National Climate Change Action Plan (NCCAP)**: Kenya's NCCAP outlines strategies for climate change mitigation and adaptation, with a focus on transitioning to a low-carbon and resilient economy. By advocating for energy efficiency and the adoption of solar thermal technologies in the tea industry, the project contributes to the reduction of greenhouse gas emissions, aligning with the NCCAP's mitigation strategies.

- **The Green Economy Strategy and Implementation Plan (GESIP)**: This plan aims to foster sustainable economic growth and development by integrating green economy principles into national development plans. The project's emphasis on sustainable energy use and the reduction of reliance on fuelwood supports GESIP's goals of enhancing energy efficiency and promoting the use of renewable energy resources.

Partners' Goals and Policy Synergies

The project's design and outcomes are well-aligned with the goals and strategies of its partners. Absolicon and Tealand, by building a market for technical equipment and services, find synergy with the project's energy-saving initiatives. WWF's focus on reducing CO2 emissions and preserving biodiversity aligns with the project's emphasis on sustainable, renewable energy practices.

Adaptability to Changing Circumstances

One of the project's strengths is its potential adaptability to changing circumstances. As energy needs and technologies evolve, the project's focus on energy audits, training, and practical solutions allows for flexibility and responsiveness to new challenges.

5.2 Effectiveness

The project, despite facing challenges, has largely achieved its expected outcomes. The partnership with WWF proved effective, and the energy-saving activities implemented in the tea factories, particularly following the energy audits and trainings in Kericho, were a significant success. These activities underscore the project's impact, demonstrating its effectiveness in fostering energy efficiency within the tea industry. However, we had plans for higher ambitions in the activities, outside what was described in the text.

Major factors Influencing non-achievement of the installation at the Chelal tea factory:

1. COVID-19 Pandemic: The pandemic significantly impacted the project, particularly in its early stages, leading to fewer visits from Sweden to Kenya than planned.

2. Shipping Challenges: Struggles with shipping to Kenya emerged as a major hurdle, causing delays and increasing project costs. The inability to deliver the thermal system as planned was a disappointment and affected the overall sentiment towards the project internally.

3. Active involvement: Absolicon has predominantly been involved in working out technical matters in Sweden. An unfortunate consequence of this where less active involvement on site in Kenya (compared to what was originally planned).

4. Communication and Cultural Differences: Challenges in communication and cultural differences, along with changes in Absolicon's contact points, slowed the progress especially between Tealand and Absolicon.

Despite not achieving the installation of the solar thermal inside the scope of the NCF engagement, a positive result was the initiation of a substantial solar thermal project by a second tea factory, inspired by the work we have undertaken in Kericho.

Maybe the unexpected part of the project was the development of three business concepts: Heat as a service; Green leasing; and the Industrial Cleantech program. When the project was created, other business concepts was envisioned. But the work in the project with WWF, financers and the contacts with tea companies, and other organisations gave growth for new ideas. Now The Industrial Cleantech Program (ICTP) has quickly built a multi-stakeholder partnership and is continuing to develop in partnership with UNIDO, the tea factories and government bodies, aiming to commercialise the findings in the Greening tea factories in Kenya project.

5.3 Efficiency

Cost efficiency

Given the complexity and innovative nature of the project, there were inherent challenges in maintaining cost efficiency. The specific activities, while potentially achievable at a lower cost under ideal conditions, incurred higher expenses due to several factors:

1. Innovative Development: The project involved developmental activities. Both technical development of a novel solar central for the tea factory, and the exploration and rejection of various business concepts and ideas. Such a dynamic and creative process, while essential for innovation, naturally led to increased costs.

2. Solar Thermal System Costs: The costs associated with the pilot installation of the solar thermal system in a new country and sector were substantially higher than in a

more established solar thermal market. This increase is typical of pilot installations but does impact overall cost-efficiency.

Comparison with alternatives: When contrasted with more conventional approaches, the project's innovative and pioneering efforts in a new sector and country may seem less operationally efficient. However, the potential long-term benefits from the innovative work should be considered in evaluating its overall efficiency.

Time efficiency

Overall, the time efficiency of the project has been below what we expected. Most activities related to energy audits, conferences, and trainings has proceeded according to plan. The work with the business concepts and multistakeholder partnership has also been time efficient.

However, the work at Chelal tea factory with the installation of the solar thermal system has extended over a large time frame. We have not been able to spend the hours planned for the installation, operation, and evaluation of the solar thermal system and some of the work to promote the solar thermal has not been possible to conduct.

The main cause has been the shipping problem that we have experienced. When planning the project, we didn't expect import of the equipment to Kenya should be a problem. We thought that CE-marked equipment that can be freely exported around the world could also be exported to Kenya. However, it turned out to exist a quite intricate system where imported goods need to adhere to specific standards, and SGS inspectors to verify this. As the Absolicon systems are tailor made, this is not easy to achieve.

First, the containers with solar collector we shipped got stuck in custom. Even as we submitted correct documents, they were charging high formal fees and at the same time our shipping agent we had contracted proposed we should pay "under the table" to get the equipment through custom. Moreover, the shipping agent was not honest with us, inflating the fees. We then changed agent but found that the first agent then distorted information to the custom to hurt us. In the end, the goods were released without us paying anything under the table and with the documents we had submitted.

The second shipment was the solar central, substantially more complex equipment containing pressure vessels, pump, sensors, and tank – all controlled by a Siemens PLC. The solar central was developed in Sweden for the project and is innovative as it allows the tea factory and the solar field to operate fully separated from each other. The key is an air preheating system with four large fans and an energy storage in an unpressurised storage tank. The system has the CE-mark.

However, when preparing the shipping documents for the second shipment, we discovered that the supplier of the fan units did not agree to release test data necessary for the SGS inspection. Also, the piping work was not done by a company having a certification not required in EU regulations, but that was required in the standard.

This started a long process to find some work around. We searched for different shipping agent and consultants to help us with little success. Finally, we discovered that if the equipment was disassembled into small parts and sent with air freight, the demands on the shipping documents was on a level we could handle. We started by sending a first pallet with this documentation. When that safely arrived without custom problem, we shipped the remaining pallets.

The root problem was Absolicon's and Tealand's lacking experience of import procedures. The project then failed to get KTDA resources to solve the problem. We were slow in understanding the challenges in the custom procedure, and once we thought we had solved one certification challenge, there were others we had not seen. We were also slow in thinking outside the box to find solutions.

We are happy that the all the goods are now in Kenya, but for future export to Kenya, we'll be very careful with how we organise import procedures.

5.4 Impact

Looking back at the project Greening tea industry in Kenya a few years from now, hopefully a few important results of the project will be seen:

1. A larger emphasis on energy audits and energy savings in the tea factories. The project has shown that there are substantial energy savings with short payback times available for the tea factories. The three participating tea factories has with practical examples showed that it is both environmental, good, and financially feasible to conduct energy saving.

2. The project has opened the eyes of the tea industry for solar thermal solutions. There is a big interest in replacing eucalyptus with solar thermal energy, something that has been shown in the different activities during the project. With the partners committed to complete the solar thermal installation in Chelal tea factory, it is likely that many tea factories in Kenya have adopted solar thermal in a few years.

3. The Industrial Cleantech Program is an innovative business model that has big potential to change the way the industry in Kenya and other countries can implement energy saving and renewable energy. The multi-stakeholder partnership that has developed around the concept is growing and if the program is successfully initiated, it can have a substantial impact.

5.5 Sustainability

There is a high likelihood for the positive effects of the project to persist, and potential for a substantial scale-up of the results:

1. The positive effects from the energy-saving activities that are a result of the projects will persist many years after the project has been completed. The energy-saving activities are very profitable and will not be cancelled.

2. The energy training that has been conducted with the employees of the tea factories will continue to operate the equipment and uphold their knowledge about the systems.

3. The Business Concept Industrial Cleantech program will, if it started, have its own financing, staff, and activities that will continue for many years, as indicated now from the multi-stakeholder partnership. If started, that will be the most important legacy of the Greening Tea factories in Kenya project.

A result of the project is the increased awareness of the potential to use solar thermal to reduce the dependence on firewood. This has been seen as other tea factories has inquired to build solar thermal systems.

According to the agreement between KTDA, Absolicon and Tealand, the 198 m2 solar thermal system at Chelal tea factory will be completed in Q2 2024. It will in that case contribute to the sustainability effect of the project:

1. To be the pilot installation it was supposed to be and, for many years stand as a demonstration of how solar thermal can replace firewood.

2. Save 150 tons of firewood and 150 tons of CO2 per year in the Chelal tea factory, corresponding to 6 hectare of eucalyptus plantation.

5.6 Coherence

There are other projects looking into energy saving activities, mainly looking at electricity saving. The Greening tea factories in Kenya used the results from the energy audit and the energy saving activities to develop three distinct business concepts. The big interest in the Industry Cleantech program shows that there is no duplication of this development in Africa. The project has felt a good support from all actors, both organizations and government entities in the work.

The project has influenced stakeholders to think more about energy saving and solar thermal, which has synergies with efforts to reduce energy consumption and increase renewable energy.

It is possible to run coordination and harmonization with electricity saving projects, complementing with the project's view on heat consumption and solar thermal.

If the business concept developed will work in Kenya, it is very likely that it can spread to other sectors in Kenya and to many other countries.

6. INNOVATION

The project has many innovative characteristics. It is by design created to foster innovation, both technical, financial, and organisational:

1. The development of the solar thermal system for tea industry is the first in the world using high temperature parabolic troughs to preheat air in a tea drying process. The solution incorporates a decoupled preheating unit with energy storage tank, a robust and stand-alone solution to a complex heating challenge.

2. The innovative nature of the business concepts, drawing from existing models and adopting them to the tea industry's need. All three business concepts have innovative components that reduce the cost for energy saving and renewable energy in tea industries.

7. POTENTIAL FOR SCALING UP AND FOLLOW-UP INVESTMENTS

The project has been designed to create solutions that can be scaled up and replicated. All three main outcomes of the project have shown good opportunity to be upscaled and spread in Kenya.

1. The method of doing energy audit and then energy saving activities has shown to have a short payback time and easy installation of new technology. This method of conducting audit both on electricity and heat opens many opportunities for big savings in the tea industry. And the financial drive should be enough to scale up those activities, at least those with the lowest and shortest payback time.

2. The solar thermal technology. In all activities, there has been a big interest from the tea industry in solar thermal as a replacement for buying and burning eucalyptus firewood in the tea drying process. As the partners have committed to complete the installation at Chelal tea factory, there will be a working pilot installation for solar thermal in tea processes in Kericho for tea industries to be inspired from. However, solar thermal is still in an early stage in Kenya, and it's likely that more activities are needed before a commercial market develops.

3. Upscaling of the business concepts is already underway. If the business concept is materialized into an organization with financing and staff, a rapid upscale of the concepts and energy-saving elements developed in the project is imminent, not only in Kenya, but if successful, in East Africa.

8. RISKS

Unfortunately, the risks identified in the project could not be mitigated in a satisfactory way, even though we saw them early in the project.

The shipping risk materialized in the beginning of the project and turned out to be much more complicated than anticipated. The combination of stringent technical requirements on import does not fit well to innovative solar thermal solutions.

Also, the risk of poor communication was a well-known risk throughout the project, but not enough resources has been allocated to solve this problem.

The unexpected risk with Corona was maybe the smallest problem. It stopped operation for a period, but it was not damaging the project in total.

In retrospect, knowing of the risks from the beginning, the project needed a complementary technical partner in Kenya and a shipping expert. The solar central should have been manufactured to comply with custom rules, and not only EU regulations.

Some of the risks remain in the finalization of the solar thermal installation, specifically shipping and finding the right materials & competence when installing the solar thermal central and connecting it to the solar field.

9. MONITORING AND EVALUATION

The project has been clearly defined with milestones, deliverables, and indicators. Those has been monitored inside the requirement of an NCF grant.

The energy efficiency measures proposed in the project and implemented by the tea factories has had follow up and evaluated as part of the tea factories energy plans.

10. LESSONS LEARNT

The key lesson is that it is not enough with CE-mark and high technical standard on the technical equipment shipping equipment to Kenya need to be taken seriously for a company that wants to make business there. The custom process and agent handling is in our opinion something that is holding Kenya back from developing. We cannot recommend companies trying to enter that market without a local partner that knows exactly how to bring the goods into the country.

Another lesson is to not describe the activities and milestones in this kind of long and innovative project too detailed as learnings along the way will affect the project. The outcome of the project has in many ways become better than what we

expected with the multi-stakeholder partnership forming around the business concept results. But more emphasis could have been put to the innovative processes in the different steps.

Also, a mayor lesson is the importance of "boots on the ground". The project management need to actively involve locally. Absolicons project manager was during the first period of the project visiting Kenya, but the second project manager had problems with obtaining visa for traveling outside Sweden.

11. OUTREACH

The inauguration workshop in March 28th 2019 at Sarova Stanley Hotel gathered over 30 people and brought together many of the stakeholders, from Eng. Pavel Oimeke, Director General Energy and Petroleum Regulatory Authority to the Deputy Gouverneur of Kericho, Susan Kikwai, and the tea factory managers. Then, in the very start of the project, the TV program Smart Farm did a news session about the project with interviews in Kericho of both Chelal manager and Absolicon project manager that conveyed the objectives of the project:

- YouTube video: Smart Farm - Tea Firms Turning To Solar Energy

The most important dissemination has been in dialogue with the tea factories during the training and the energy audits, and all the mayor factories and some smaller tea factories has been involved e.g. KTDA, Finlays, Unilever, Camellia (EPK) and Sotik.

At the final seminar Sept 28th 2023 in Nairobi, most of the large tea companies in Kenya were represented – KTDA, Finlays, Unilever, and Sotik. The seminar gathered 15 people and focused on results of the project and the continuation in the form of the Cleantech Program proposed as one of the business concepts. Representatives from SIDA, the Swedish ODA, pledged to support the concept and presented how to work with UNIDO to develop it further.

The reports of the projects are mainly distributed electronically on the websites of the partners and by email to stakeholders and organizations.

12. FINANCIAL SUMMARY

Table 1. Project financing per partner

Expenditures (EUR)	NCF	Absolicon	WWF Kenya	Tealand	**Total**
Absolicon	251 207	65 728			**316 935**
WWF Kenya	40 629		4 277		**44 906**
Tealand	15 436			4 803	**20 239**
Total	**307 272**	**65 728**	**4 277**	**4 803**	**382 080**

13. CONCLUSIONS AND RECOMMENDATIONS

To introduce new technology and new ideas in a country far from home is a big challenge. The Greening Tea Factories in Kenya project started with an idea after Absolicon meeting with Parminder Singh from Tealand in Stockholm in 2017. It was followed by an investigating project and then the application to NCF in 2019. After these 7 years since we first started, we have learned a lot about developing ideas and projects.

We have become more respectful for the challenges working across the globe and what resources are needed to communicate. In many ways, the project has been successful, coming with the right ideas in the right time, and finding a good response to all the basic concepts.

All partners in the project have had their different strong and weak points. This could have been taken better into account when organizing the project from the start and with fallback solutions for potential shortcomings.

The project has in some ways surpassed our expectations. A scale up of the concepts developed is underway that will have a big impact. The delay of the solar thermal installation has affected the project less than initially was expected. The majority of deliverables has not been put off, and the interest in solar thermal have nevertheless been increased.

The area of energy saving, and renewable energy has many opportunities and too little is happening today. A recommendation would be to focus on those critical areas that also decrease the costs of production in developing countries' industries, making them more competitive. The project has successfully created several of the tools that might be useful, but many more innovations are needed, both technical solutions and business concepts, before the work is done.

Annex 1 Project completion fact sheet

Project Name:	**Greening tea factories in Kenya**		
Project no.	NCF7, C7-0129		
Country:	Kenya	**Financing:**	
		EUR	**%**
Nordic Partner:	Absolicon Solar Collector AB	65 728	18%
Local Partner:	WWF Kenya	4 277	1%
	Tealand	4 803	1%
	NCF grant disbursed	307 272	80%
	Total	**382 080**	**100%**
Classification:	Mitigation		
Project cycle:	Project start date: 01/01/2019 Original closing date: 21/6/2021 Actual closing date: 09/30/2023		
Short project description:	The project aimed to enhance energy efficiency in Kenya's tea industry, starting with energy audits in three factories and implementing measures like boiler efficiency improvements, motor replacements, and energy-efficient lighting. 64% of proposed activities were implemented with a 7.5-month average payback time. The project has created interest in solar thermal solutions within the tea industry, despite delays in importing and installing solar thermal technologies. However, the solar thermal pilot installation will be ready post-project. Finally, the project has development business models to sustain energy efficiency and solar thermal adoption beyond the project's lifespan. The "Industrial Cleantech Program" is one of the business concepts developed and is now supported by a multi-stakeholder partnership including tea factories, WWF, UNIDO, ODA agencies like SIDA, and regional banks, focuses on providing vetted energy solutions with integrated financing options. The work in the project for energy savings and renewable energy installations across the tea industry represents a significant step towards sustainable industrial practices in the region, leveraging both technological innovations and collaborative partnerships.		
Project performance:	**Expected Outcomes and Outputs**	**Achieved**	**End-of-project status**
	Outcome 1: Tea factories have increased capacity on energy efficiency and are prioritizing implementation of energy efficiency measures	Partly	3 tea factories did energy audits
	Output 1.1: Capacity built on energy efficiency, eucalyptus cost & challenges and emissions reductions potential	Yes	24 persons formally trained
	Output 1.2: Tea factories have well-developed energy efficiency plans with energy assessment of the energy consumption in the tea factory before and after the activities.	Yes	3 tea factory baselines established, and energy plan(s) developed.
	Outcome 2: Adoption and installation of Solar PTC technology and other energy efficient measures by tea factories results in reduction of GHG emissions, energy cost savings.	Partly	Solar thermal system to be installed Q2 2024.
	Output 2.1 Solar PTC projects are planned, produced and shipped from Sweden.	Yes	198 m2 of solar collectors shipped to Chelal tea factory
	Outcome 3: There's increased awareness of solar PTC technology within Kenya's industrial and financial sector and at least 2 additional companies is interested in testing the technology	Yes	3 factories saved 650 ton of CO2 with 7,5 month payback. 2 additional tea

			factories interested in solar thermal.
	Output 3.1: Kenya's industrial sector is sensitized and is adopting use of solar collector technology.	Yes	Three green business concepts and financial tools. 10+ meetings to develop methods. One multi-stakeholder partnership developed.
	3.2: Development and presentation of project impact assessment report	Yes	Impact report and business plan developed and presented
Climate change outcomes and impacts:	In three tea factories, 1442 ton of CO2 saved. 7.5-month payback time. Firewood energy saving activities and electricity saving activities implemented that reduce the energy cost in the factories 4% - 8%.		
Development outcomes and impacts:	Solar thermal and energy efficiency sensitization. A multi-stakeholder partnership built to implement the financial concepts and business models created and to upscale the concepts of the project. The upscale is done with UNIDO – first in Kenya tea industry and then to other industries and potentially to more countries in East Africa.		

NCF core indicators

NCF core indicator	Results (quantitative)			Clarifications/Means of verification
Number of beneficiaries reached	women		0	N/A
	men		0	
	total		0	
Number of people with increased resilience to climate change	women		0	N/A
	men		0	
	total		0	
Number of people with improved livelihoods	women		0	N/A
	men		0	
	total		0	
New decent jobs created	full-time	women	0	N/A
		men	0	
		total	0	
	part-time	women	0	
		men	0	
		total	0	
	seaso-nal	women	0	
		men	0	
		total	0	

Annex 2 Results Framework

Expected outcomes and outputs	**Indicator(s):**	**Achievement of outcomes and outputs:**
Outcome 1: Tea factories have increased capacity on energy efficiency and are prioritizing implementation of energy efficiency measures	Indicator 1.1 Number of factories to have participated in energy efficiency capacity building and energy audits.	*Partly achieved: 3 (8)* *Three factories subjected to energy audits and have conducted energy saving activities. Two of the factories have been capacity strengthened on energy efficiency*
Output 1.1: Capacity built on energy efficiency, eucalyptus cost & challenges and emissions reductions potential	Indicator 1.1.1 Capacity building on energy efficiency. Training of staff members and workers of tea factories in energy efficiency measurements	*Achieved: 24 (20)* *A formal training was conducted in early March 2021 and attracted 24 participants, including 4 women and 20 men.*
Output 1.2: Tea factories have well-developed energy efficiency plans with energy assessment of the energy consumption in the tea factory before and after the activities.	Indicator 1.2.1 Tea factory baseline established, and energy plan(s) developed.	*Partly achieved: 3 (8)* *Three factories undertook baseline assessment and conducted energy efficiency audits. See report 'A2. Greening tea factories by energy audit and energy savings' for further details.*
Outcome 2: Adoption and installation of Solar PTC technology and other energy efficient measures by tea factories results in reduction of GHG emissions, energy cost savings.	N/A	*N/A*
Output 2.1 Solar PTC projects are planned, produced and shipped from Sweden.	Indicator 2.1.1 Solar PTC produced and shipped from Sweden	*Achieved: 198 m2 (396 m2)* *NCF agreed to reduce this target with the project team, and the indicator has successfully been met with the 198 m2 that was shipped to the Chelal tea factory.*
Output 2.2 Energy efficient measures and PTC are adopted by the tea factories based on recommendations from previous output.	Indicator 2.2.1: Installation of pilot installations of PCT	*Not achieved.* *Installation planned to Q2 2024 in accordance with discussions with NCF and a partner agreement signed 28/9 2023.*
	Indicator 2.2.2 Number of recommended activities adopted.	*Achieved: 64% (50%)* *64% present of the recommended activities were implemented by tea factories. See report 'A2. Greening tea factories by energy audit and energy savings'.*
Outcome 3: There's increased awareness of solar PTC technology within Kenya's industrial and financial sector and at least 2 additional companies is interested in testing the technology	Indicator 3.1 CO2 reduction during the duration of the project	*Achieved: 1442 ton (300 ton)* *See report A2. Greening tea factories by energy audit and energy savings*
	Indicator 3.2 Number of green business concepts tested	*Achieved: 3 (3)* *The target was meet with development*

		of three concepts that are detailed in the report, 'A1. Three green business concepts and financial tools'.
Output 3.1: Kenya's industrial sector is sensitized and is adopting use of solar collector technology.	Indicator 3.1.1 Number of multi-stakeholder partnerships developed	*Achieved: 1 (1)* *Achieved through the creation of the "Industrial Cleantech program" detailed in this report.*
	Indicator 3.1.2 Program document for financial tools	*Achieved: 1 (1)* *The target was meet with development of three concepts that are detailed in the report, 'A1. Three green business concepts and financial tools'.*
	Indicator 3.1.3 Meetings (pcs) to find financing methods	*Achieved: 10 (10)* *Meetings were held ongoingly with stakeholders culminating with the final seminar held on 28 September 2023.*
3.2: Development and presentation of project impact assessment report	Indicator 3.2.1 Report from the end-term evaluation on project impact and operational excellence.	*Partially achieved: 1 (1)* *This completion report contains an end-term evaluation of the project as it was implemented. The matter related to 'operational excellence' can only be assessed once the installation is in place at the Chelal tea factory.*
	Indicator 3.2.2 Impact report and business plan	*Achieved: 1 (1)* *See separate document 'A3. Impact report and business plan' for further details.*

Annex 3 Pictures

Eng. Pavel Oimeke, Director General EPRA, officially launching the project. ©WWF-Kenya/Judy Kosgei

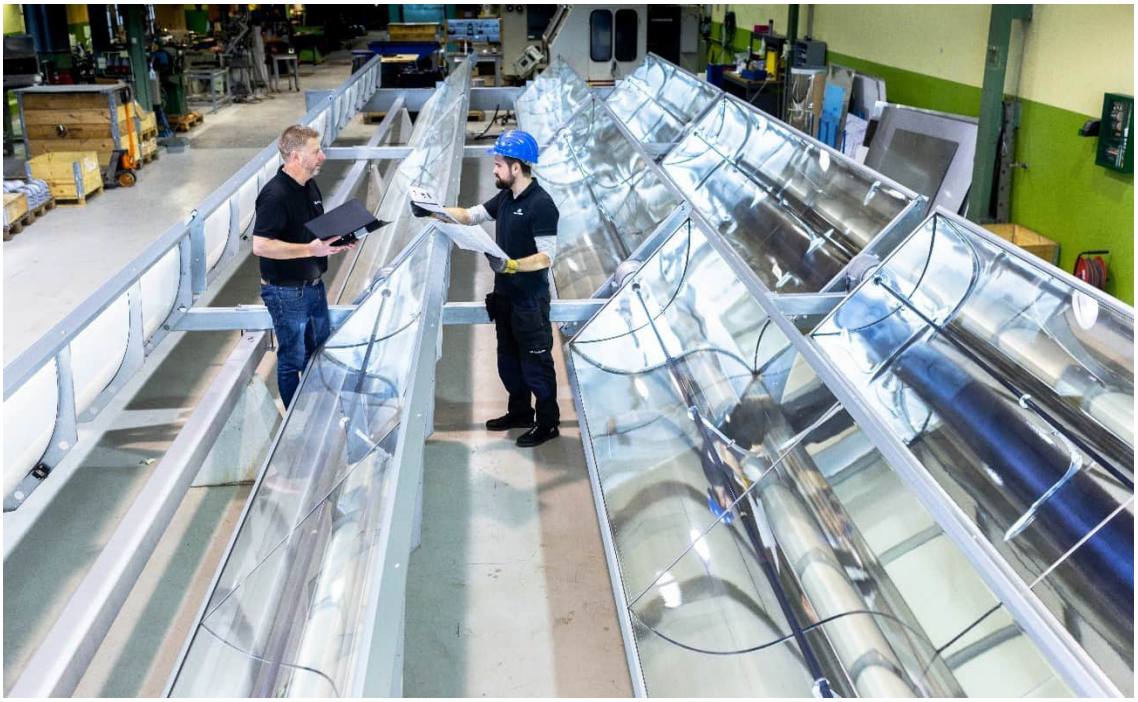
Group Photo during the launch of the project at Sarova Stanley Hotel ©WWF-Kenya/Judy Kosgei

Fuelwood reserves for use at Chelal tea factory ©WWF-Kenya/Judy Kosgei

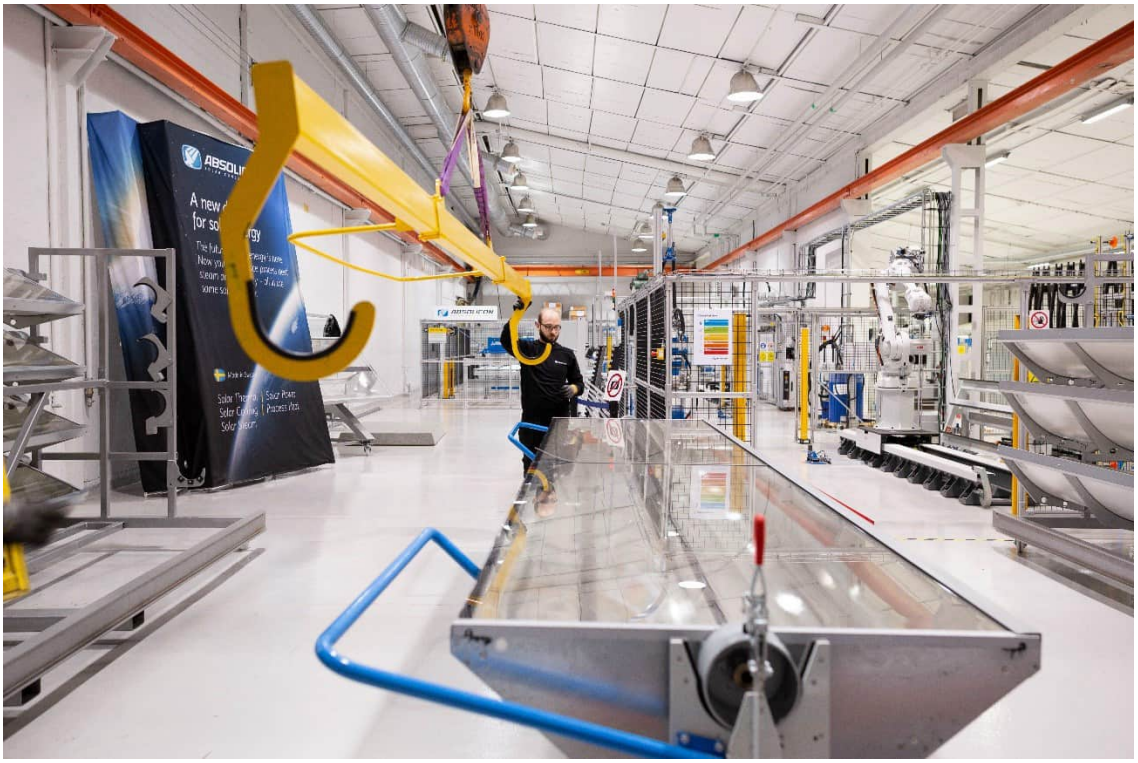
Stacks of fuelwood for use in the boiler at Chelal tea factory ©WWF-Kenya/Judy Kosgei

Christer Pekkala and Krzysztof Adamczyk preparing the shipping of solar collectors in Milestone 1. Photo: Absolicon

Christer Pekkala and Krzysztof Adamczyk undertaking testing of tracking system in Sweden before shipping of solar collectors in Milestone 1 to Kenya Photo: Absolicon



Christer Pekkala and Krzysztof Adamczyk undertaking testing of tracking system in Sweden before shipping of solar collectors in Milestone 1 to Kenya Photo: Absolicon



At Absolicon, Rames Shabani is moving a solar collector to transport wagon. Photo: Absolicon

Eight solar collectors loaded in transport wagon at Absolicon waiting for transport to Kenya. Photo: Absolicon

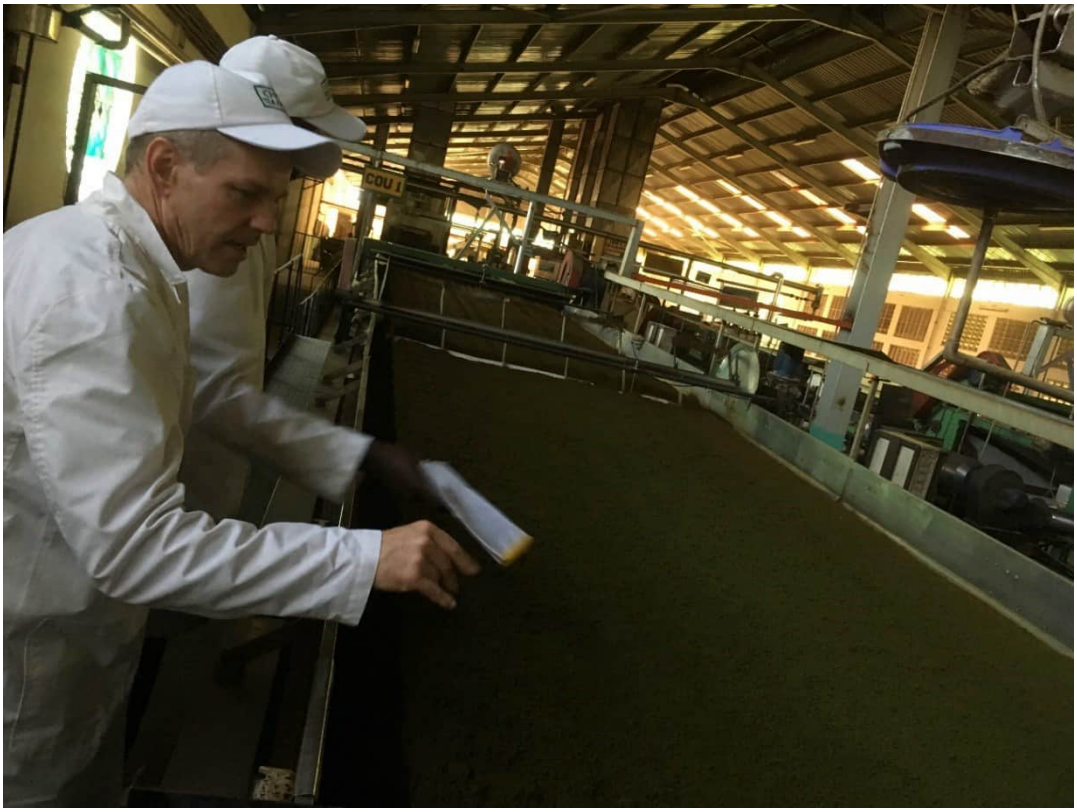
Solar collectors loaded in container in Sweden for shipping to Kenya. Photo Absolicon

Parminder Singh from Tealand. Photo: Absolicon

Joakim Byström, CEO of Absolicon, at Chelal tea factory. Photo: Absolicon

Tea leaves. Photo: Absolicon

Stefan Jonsson, Glofin, inspecting the air intake where the preheater for the tea dryer at Chelal Tea factory will be installed. Photo: Absolicon



Stefan Jonsson, Glofin, inspecting tea process in Chelal tea factory. Photo: Absolicon

Firewood boiler at Chelal tea factory. Photo: Absolicon

Boiler house at Chelal tea factory. Photo: Absolicon

Screen dumps from Smart Farm news flash.
[SMART FARM | Tea Firms Turning To Solar Energy (youtube.com)]

Solar central for Chelal waiting for shipping from Sweden to Kenya. Photo: Absolicon

Fan unit to be installed at the tea dryer in Chelal tea factory waiting for shipping. Photo: Absolicon

Solar central and fan unit disassembled to fit into 80 x 120 pallets for air fright to Kenya. Photo: Absolicon

Annex 4 Other supplementary deliverables/documentation/links

A1. Three green business concepts and financial tools

A2. Greening tea factories by energy audit and energy savings and

A3. Impact report and business plan

Annex 5 Impact story

The tea industry in Kenya relies on traditional, energy-intensive methods for tea processing. Factories extensively used eucalyptus firewood for drying and withering tea leaves, leading to high operational costs and substantial carbon emissions.

The lack of energy efficiency has a negative impact on the environment, but also strains the factories' finances. Competition from India and China is demanding cost control on all areas of operation, not at least energy.

The project aimed to revolutionize these practices. Over four years, partners collaborated to conducted energy audits and introduce solar thermal technology and energy-saving measures in the tea drying process. In parallel, business models were developed to address the upscaling of the findings.

As the project concluded, the participating tea factories – Chelal, Ngorongo, and Litein – have demonstrated how energy efficiency activities can be implemented. Following the energy audit, the tea factories initiated a wide range of activities to reduce their energy consumption. In average, the activities had a payback time of 7.5 months and will during a 2-year period save 1442 tons of CO2.

The introduction of the concept of solar thermal technology, despite challenges in installation, has still highlighted a new way to reduce the use of eucalyptus firewood, a significant step towards environmental sustainability.

The project's most notable impact is seen in the tangible shift in the tea industry's approach to energy efficiency. Especially KTDA is now investigating methods to upscale the results of the project. The solar thermal pilot installation at Chelal Tea Factory, to which solar collectors has been delivered but not yet installed, will serves as a model, inspiring other factories to adopt similar technologies.