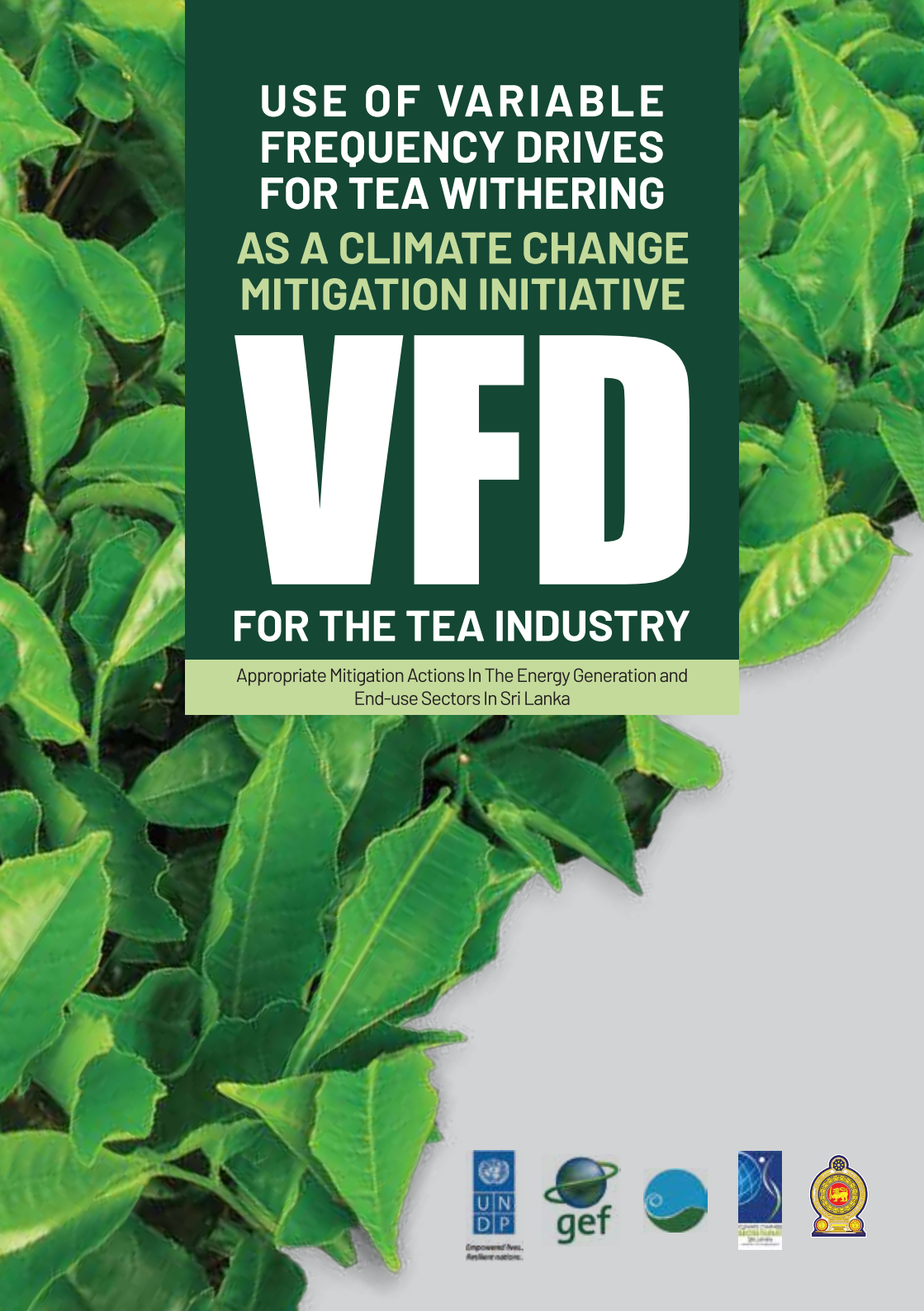
USE OF VARIABLE FREQUENCY DRIVES FOR TEA WITHERING

AS A CLIMATE CHANGE MITIGATION INITIATIVE

VFD

FOR THE TEA INDUSTRY

Appropriate Mitigation Actions In The Energy Generation and End-use Sectors In Sri Lanka



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CONTENTS

The Issue

Climate change requires urgent global action. In Paris, in 2015, every country in the world pledged to curb emissions of greenhouse gases and exchange technical and financial resources required to stem runaway climate change and contain warming at around 2 degrees centigrade.

Each country formulated its climate promise in a nationally determined contribution (NDCs) to global efforts. While locally defined and prioritized, these climate change mitigation efforts will be globally monitored to ensure that the overall emissions target remains in sight.

As such, Sri Lanka was also required to identify suitable low-carbon interventions in key sectors. Energy, needless to say, is the most important mitigation sector both locally and globally. Other sectors include transport, industrial processes, waste and forestry.

A four year project funded by the Global Environment Facility (GEF) and co-implemented by the Sri Lanka Sustainable Energy Authority (SLSEA) and the Climate Change Secretariat (CCS) set out to identify suitable mitigation options for the energy sector, develop policy tools, data and reporting systems and an institutional framework to develop, finance and monitor nationally determined mitigation actions.

Appropriate Mitigation Actions in the Energy Generation and End-Use Sectors in Sri Lanka (NAMA Project)

(2015-2019) is funded by the Global Environmental Facility (GEF). The Ministry of Power, Energy and Business Development is the Executing Agencyand the United Nations Development Program (UNDP) is the "Implementing Partner" of the Project.

The project focused on:

- Policy analysis tools to support and prioritize nationally appropriate mitigation options
- Developing a grassroots-to-centre data management system in the energy sector
- Establishing a monitoring, reporting and verification (MRV) system for the energy sector
- Establishing an institutional structure for energy sector climate actions and
- Leveraging public and private investments for mitigation interventions.

The project selected three technologies to pilot this process:

1. Biogas - as a waste management solution for individual, institutional and industrial applications
2. Variable Frequency Drives (VFD) - as an energy efficiency improvement measure for tea factories
3. Solar PV with battery energy storage, for domestic consumers as a renewable energy generation method.

This booklet presents the project experience in promoting and facilitating the application of VFD technology in the Sri Lankan Tea Industry. Case studies are selected to highlight the key outcomes of the project.

An Opportunity

The beautiful highlands of Sri Lanka have been producing the world's finest tea for many centuries. As the fourth largest tea producer and second-largest tea exporter in the world, Sri Lanka's economy relies on revenue generated by the tea industry. Presently, the tea industry is contributing to 2% of national GDP while generating 65% of export earnings in the agriculture sector. More than two million people – around 10% of the total population – depend on the earnings in this sector. Therefore, the development of this industry, with sustainable initiatives, is of paramount importance to the country.

Approximately 700 tea factories operating in the island use around 235 GWh of energy annually, which is 7% of the total industrial sector requirement. In the tea industry, around 8% of the production cost accounts for energy. Biomass is the major thermal energy source in the tea manufacturing process while electricity is used for running the motors. Withering, rolling, drying, sifting and packing, as well as lighting, require electricity in the tea manufacturing process, while the most amount of electricity is needed for withering and rolling.

According to research and analysis conducted by the Sri Lanka Sustainable Energy Authority in 2013, the implementation of energy-efficient measures – to the best achievement level – among all factories can bring a total annual saving of 33.5 GWh of electricity and 42,300 tons of firewood in the tea industry.

Realizing this energy-saving potential, NAMA Project aims to help the Sri Lankan Tea Industry to become more energy-efficient and reduce its impact on the environment as a part of climate change mitigation actions.

Focus Area

Tea processing primarily involves the removal of moisture in tea leaves through withering, rolling, fermentation, and drying. The quality of the tea depends mainly on the withering process, which contributes to a major share of costs in terms of processing time and electricity consumption.

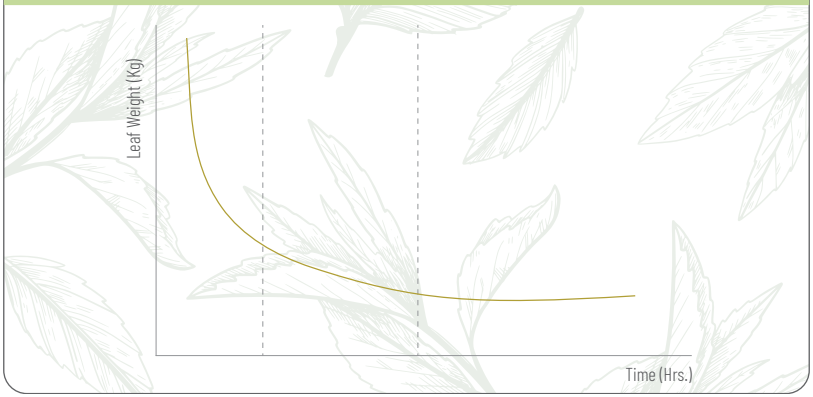
Tea withering is done by spreading green tea leaves on dryers known as withering troughs. During the early stages of withering, moisture on the surface is removed and this is followed by the removal of embedded moisture. Each withering trough uses large amounts of energy as a motor needs to be driven to power fans that aerate the tea leaves and remove moisture.

The moisture removal rate from green tea leaves is rapid at the initial period and reduces with time. The airflow requirement of the withering trough also follows a similar curve, while airflow can be reduced after the surface moisture is removed.

The normal practice is to operate the withering fan throughout the withering process at full speed. Due to the absence of a speed control mechanism, measures like controlling inlet air louvres, covering air inlets, and opening rear trough doors, are used for this purpose.

NAMA Project focused on reducing energy consumption during the withering process by introducing a Variable Frequency Drives (VFD) mechanism.

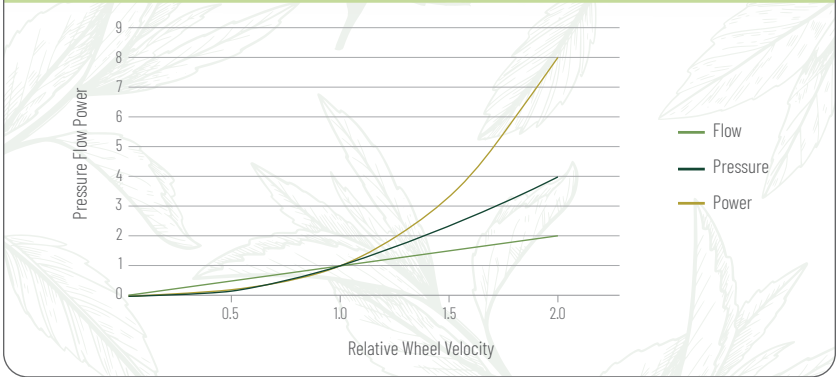
"Figure 1: The variation of moisture removal rate of tea leaves with time"



What is VFD?

Most commonly known as an inverter or variable speed drive, VFD is a type of electronic motor controller that drives and varies the speed of an electric motor. This is an appropriate mechanism for controlling the air needed during withering as it can blow the required quantity of air by reducing the fan speed to match the exact requirement. The electrical energy input to the motor varies with the rotating speed of the motor, resulting in a saving in energy demand.

"Figure 2: Affinity low"
Wheel Diameter Constant, Wheel Velocity Changing



The power consumption of the motor is inversely proportionate to the cube of the motor speed. Hence, power consumption can be reduced to one eighth by reducing speed by half.

- **Flow reduced from 100% to 80%**
  Power drops from 100% to >51%
- **Flow reduced from 100% to 50%**
  Power drops from 100% to >12.5%

Though VFDs were introduced to the Sri Lankan tea industry in the 1990s, it was not embraced as a popular energy-saving option by the sector. NAMA project identified the following reasons for the rejection of this technology.

- Lack of awareness of the energy savings achieved
- Frequent failures due to lightning and harsh operating conditions
- Poor aftersales service by VFD suppliers

In order to prove its value, NAMA Project facilitated the installation of 1000 VFD units in tea factories. This pilot project was implemented together with awareness creation, technical guidance, and financial assistance.

Work Done

The Project provided the following remedial actions to facilitate technology penetration:

Issue identified	Action taken to overcome the issue
Frequent failure due to lightning	Mandatory to have a Class II **Surge Protection Device**
Frequent failure due to dust	Should have a high Ingress Protection rating **(IP54 or above)**
Lack of awareness about savings	Energy savings monitoring portal introduced Online monitoring application developed
Poor aftersales services by VDF suppliers	Selected and pre-registered qualified and reliable organizations

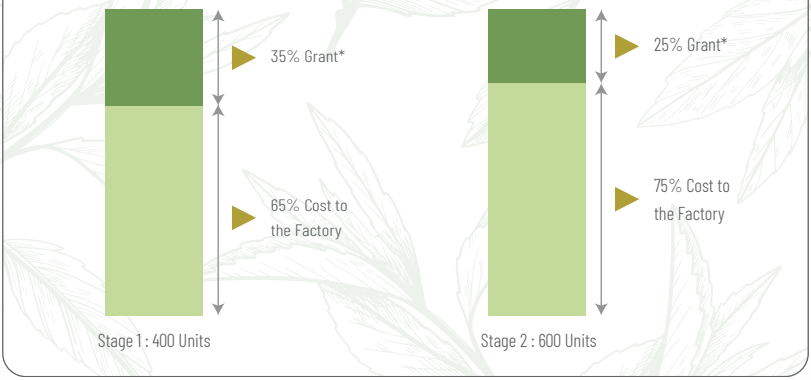
Industry Awareness

Creating industry awareness through practical demonstrations and success stories was one of the main initiatives undertaken by the Project. With the background information collected, the project team developed a technical specification for VFDs and guidelines for installation. Minimum requirements to be fulfilled by VFD suppliers were also identified. Sixteen suppliers who met the minimum requirements and were capable of supplying VFDs with identified minimum features were registered to supply VFDs under the project. Technical assistance was provided by the project to identify correct products, and after-installation inspections were carried out by a group of independent Chartered Electrical Engineers, verifying these installations were in line with the specifications and guidelines provided.

Project Subsidy

The programme assisted over 70 tea factories with a part-financing subsidy to install 590 VFDs under a strict quality control and quality assurance process. At the initial stage, the project grant assistance was 35% of the total cost of the VFD and its installation. The grant rebate was reduced to 25% in subsequent stages.

Figure 3: Project subsidy scheme



MRV of Energy Savings

NAMA Project introduced a web-based energy savings monitoring portal. At the factory level, a responsible officer has to feed 2 parameters on a monthly basis for each VFD, while the system automatically calculates the energy saving achieved by the unit, as well as the emission reductions. This monitored data, alongside with other useful information, can be observed remotely by any authorized person – from the factory level to top management – through a web-based monitoring portal.

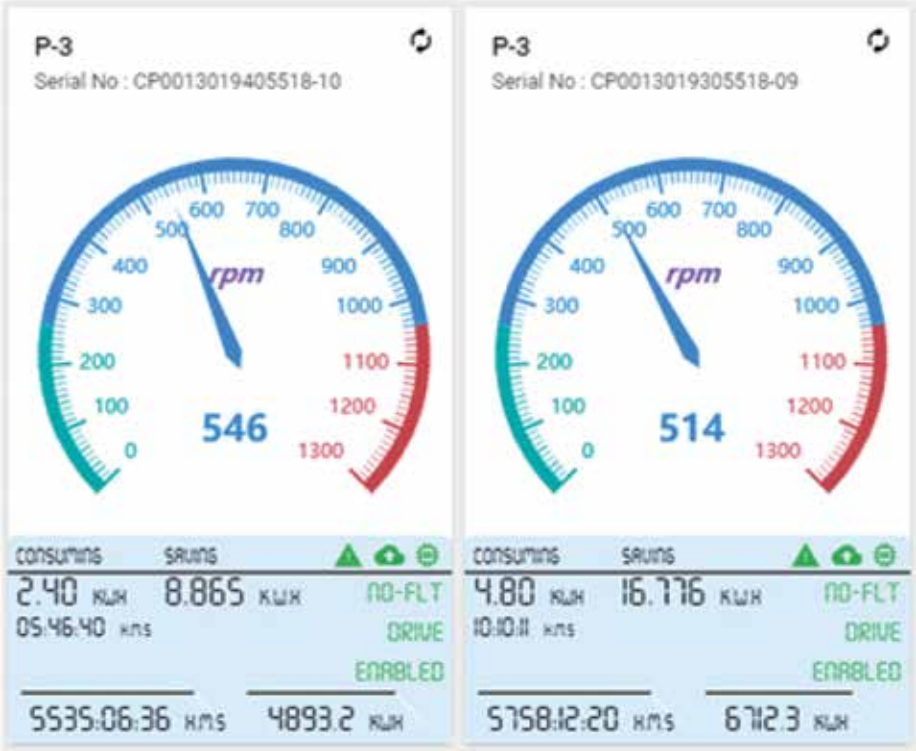
Figure 4: Web based Energy & GHG Emission Savings Monitoring Portal

VFD Online monitoring Application

The NAMA Project developed a VFD online monitoring application to instantly check the status of VFDs running in tea factories from mobile devices. Comprehensive training was provided to executives and operational staff of tea factories on the functioning of VFDs, and energy savings were systematically accounted through the web-based energy management portal.

The installed systems are capable of withstanding a dusty environment and monitor the energy consumption of the connected motor, giving factory owners peace of mind and creating awareness; eliminating doubts related to energy savings.

Figure 5: VFD Online monitoring Application



Final Outcome

Typically, observed energy savings are in the range of 20%-30% of the baseline energy consumption. Beneficiaries of the project claim that they have managed to achieve a uniform wither. Hence, the quality of tea produced has increased, resulting in an increase in high-grade tea with higher value and a reduction in refused tea.

A more significant outcome was the leverage of private sector financing for energy-saving activities with GHG emission reductions; gaining more than USD 500,000 investment into the programme.

No. of Factories Supported	70
VFDs Installed	590
Total Capacities	4,032.5 kW
Expected Energy Saving	3.387 GWh/annum
Emission Reduction	2,438 tCO_2 /annum
Programme Support	USD 159,000
Co-investments by the Factories	USD 511,000

Financial Gains

The energy-saving potential of VFDs is in the range of 20% to 30%. With such energy savings, the cost of implementation can be recovered within 3 years. Tea factories with their own estates can enjoy a higher energy cost saving as they have the flexibility to reduce the withering rate – and thereby energy consumption. A uniform wither has resulted in an improvement in product quality and a reduction in the quantity of refused tea. These additional benefits bring down the actual payback period further.

Way Forward

Going a step further, the NAMA project has supported interested tea producers to introduce VFDs for other applications in tea factories. Tea factories have shown interest in installing VFDs for airflow control fans of their furnaces and boilers, as it results in an indirect saving of fuelwood in addition to electrical energy savings. A few other industries were also supported by the project to introduce VFDs for energy conservation and process control applications.

Case Studies

VFD Success Story: VFD works wonders for Maskeliya Plantations

Background:

Maskeliya Plantations and Namunukula Plantations (Uva Range) are the two tea plantation companies owned by Richard Pieris and Company. Maskeliya and Namunukula plantations together manage the largest land bank in Sri Lanka, and are the largest tea producers in the country. While they manage over 30,000 ha of tea plantations, the average annual tea production is 13 million kgs.

Energy is one of the major cost factors for tea manufacturing. The total cost of energy for producing a kilogram of tea is in the range of 25 – 30 rupees and is shared between electricity and biomass as 12- 15 Rs/kg and 10 – 12 Rs/kg respectively. With concern over energy costs, Maskeliya factories have explored efficiency improvement opportunities with basic and easy energy saving measures, such as introducing LED lamps, programming of manufacturing process rightly, and automation.

Case Study:

Maskeliya Plantations introduced Variable Frequency Drives (VFDs) to some of their factories in 1990s and early 2000s. According to Mr. Manoj Pathiraja, CEO of Maskeliya Plantations PLC, they did not implement the process completely. "People were not trained, and proper awareness was not given to all levels of factory staff. Hence, the systems were not sustained, and we have not got proper feedback after investing money," he added.

With NAMA Project support, they reverted to VFD application and achieved remarkable success. They have installed 102 VFDs in 14 factories with a total investment of LKR 18.5 million including the project grant of LKR 4.5 million. NAMA Project provided necessary training to factory staff on the effective use of VFDs for withering, as well as for monitoring of energy savings and regular maintenance of VFDs. "I visited these VFD installations and saw how they are functioning and how the process works. I observed that our withers are excellent. These things have given us new hope. If you use VFDs intelligently, with proper training and awareness, I'm sure that the quality parameters of your end products will improve. The cost of energy will come down in your factory. These are things that people in the sector will need to do together and share each other's knowledge. I can tell my colleagues to invest in a few more units and see if there are benefits. In my case, I have seen the benefits,

and have my numbers correct," Mr. Manoj Pathiraja confidently invited his colleagues in the sector.

Impact:

The cumulative energy saving for 18 months from all factories is 600 MWh and is equivalent to a financial saving of LKR 9 million. The emission mitigation resulted from the project during the period was 480 tCO2. Talking on other advantages of introducing VFDs for withering, Mr. Manoj Pathiraja said that with VFDs, they have managed to obtain the correct wither more efficiently, even during the rainy season within the normal withering period. In a few MPL factories, the airflow soon after spreading wet tea leaves in rainy days by running the motors at a speed higher than the normal running speed, which leads to a fast removal of surface moisture within a shorter time period, prior to setting back to the usual withering pattern.

Number of Factories	14
Number of VFDs installed	102
Total energy saving (as at 09/2019)	646 MWh
Proximate cost saving	9.7 mn LKR
GHG emission saved	530 tCO_2
Total investment by MPL	13.84 mn LKR
Grant Support by the Project	4.5 mn LKR

Case Studies

Case Study 2 – Pedro Tea Processing Center, Nuwaraeliya,

Background:

Pedro Tea Processing Center is located in Central Sri Lanka at close proximity to Nuwara Eliya. The tea factory is situated at an elevation of 1895 m (6200 ft). The Pedro Tea Estate is managed by Kelani Valley Plantations PLC and the Pedro Tea Factory has the capacity to produce 22,000 kgs of green leaf per day. The factory has 24 withering troughs in 3 lofts.

77 VFDs were installed in 9 tea factories of Kelani Valley Plantations PLC under the Energy NAMA Project including the 10 VFDs installed at Pedro Tea Processing Center.

Case Study:

10 of the most frequently used troughs in loft 1 and 2 of the Pedro Tea Factory were selected by the management to install VFDs. These were selected on the basis of the number of hours operated during a year.

While louvers were used previously to control the air flow, after installing VFDs, the RPM of the motor was adjusted to regulate air flow within the trough.

The factory receives green leaf 3 times a day. The troughs with VFDs are usually used to wither morning and noon leaf tea. "Morning leaf and noon leaf are partially withered by 6.30 pm and we use VDFs to maintain a lower airflow during peak hours and this has helped us to reduce our energy cost" says Estate Manager Manith Jayamanthri. "Surface moisture removal from wet leaves can be expedited by increasing motor speed initially for a short period of time" he further added.

VDFs have helped the management to properly plan the manufacturing process avoiding the idling of machinery and labour. Withering is now being planned in a way that avoids leaves from getting conjested, blocked or underfed. "By adjusting the air flow with VFDs, we are able to make the troughs ready for manufacturing one after the other. This way, manufacturing is not interrupted, and the wither does not exceed the percentage that is normally maintained," explained Mr. Jayamatnhri. A lower air flow can be maintained to avoid over withering and excessive heat generation within the leaf bed. The usual practice to avoid such circumstances is to run the motor at full speed either with closed louvers or opened rear trough doors.

Impact:

Pedro Tea Factory has saved 24.6 MWh of electrical energy in 18 months. "Assistance of VFDs to improve the product quality is more than the energy cost saving," concludes Mr Jayamanthri with a smile.

Number of VFDs installed	10
Total energy saving (as at 09/2019)	24.6 MWh
Approximate cost saving	370,000 LKR
GHG emission saved	20 tCO_2
Total investment by the factory	1.2 mn LKR
Grant Support by the Project	0.53 mn LKR

Case Studies

Case Study 3 – Dampahala Tea Factory, Matara

Dampahala Tea Factory is a privately owned factory situated in Urubokka, Matara. The Dampahala, low-grown orthodox tea manufacturing factory has the capacity to process 7000 kgs of green leaf a day. The tea leaves that are processed are collected from small tea holders in the region.

Dampahala Tea Factory has 7 troughs which were operated by adjusting the louvers when the airflow of withering troughs needed to be changed. The management of Dampahala Tea Company – with the support of the Energy NAMA Project – installed VFDs for all 7 troughs.

The factory has achieved an energy saving of 20% - 30% from the withering section after the introduction of VFDs. Further a 10% - 15% reduction of the maximum demand of the factory is also observed. In addition to saving energy, VFDs have helped Dampahala Tea Factory to achieve a uniform wither, which improves the quality of tea. "Withering is the heart of tea manufacturing. Achieving the correct wither is the main requirement in tea manufacturing; VFDs help us to get this done correctly," informs Factory Officer Chaminda Jayarathna who has 15 years of experience in the tea industry.

Being a brought leaf factory, Dampahala Tea Factory receives their leaf collection in the evening within a short time period. Therefore, efficient scheduling is an important factor to avoid machine idling and leaf congestion at the rolling room. "We plan how to effectively use troughs with VFDs to optimise the use of machinery and reduce energy wastage, depending on the amount of green leaves we receive each day," adds Mr Jayarathna.

Number of VFDs installed	7
Total energy saving (as at 11/2019)	26.6 MWh
GHG emission saved	21 tCO_2
Approximate cost saving	0.4 mn LKR
Total investment by factory	0.81 mn LKR
Grant Support by the Project	0.42 mn LKR

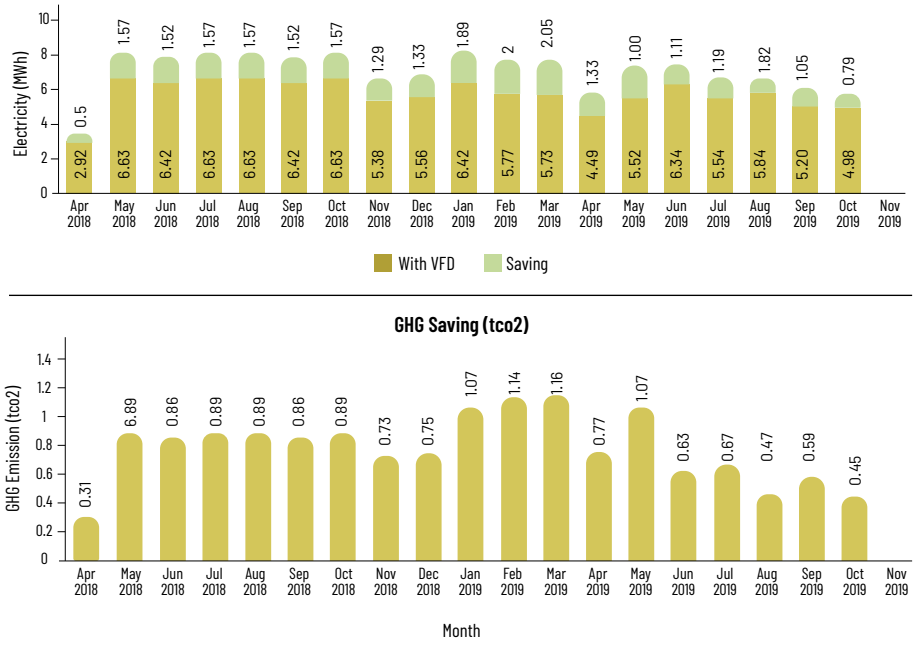
Dampahala Tea Factory

Manufacturing Method: Orthodox

Reg: No. MF 1331

Region: Low Grown

Figure 6: Verified energy savings and GHG Emission Reductions from web based monitoring portal



NO. of VFDs installed

7

Last updated month

Total Energy Saving (kWh)	Total Greenhouse Gas Emission Saving (MT)
791	0.45

Cumulative from the beginning

Total Energy Saving (kWh)	Total Greenhouse Gas Emission Saving (MT)	Total Saving: LKR
26,602	15	399,032.40

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