TRAINING NOTEBOOK

- ENVIRONMENTAL MANAGEMENT -

SUSTAINABLE ENERGY MANAGEMENT

COLEACP

This publication has been prepared by the COLEACP as part of co-operation programmes funded by the European Union (European Development Fund – EDF), the Agence Française de Développement (AFD) and the Standards and Trade Development Facility (STDF).

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Dear trainers, some advice...

WHY A TRAINING NOTEBOOK?

The 'Manuals' edited by COLEACP are valuable training materials. To write them, COLEACP approached the best experts in the field with the aim of producing a technical document for a large public on a given theme that brings together and structures most of the current knowledge. These manuals are intended to be as accurate and complete as possible, adapted to the ACP context and focused on cross-cutting issues in horticulture. But the objective was also to make them affordable, understandable and enjoyable to read by people who are not necessarily experts in the field. Nevertheless, it is a considerable effort to assimilate all the material collected in a short time.

The training manuals, which are aimed primarily at experts and the most qualified people, are often voluminous and complex, and it was necessary to help the expert trainers to identify the most important elements to retain, and to collect for them a list of 'key messages' to be disseminated to learners during COLEACP training. This Training Notebook is therefore a valuable and practical tool that is at your disposal to help you prepare your training on the topic covered in this Booklet.

WHAT DOES THE TRAINING NOTEBOOK CONTAIN?

Each Training Notebook contains:

1. The list of materials to be delivered to participants during the training

This is a summary table of contents of the Training Manual. This list allows you to have an **overview of** all the **main points that** will have to be covered during the training. The **order of the list does not necessarily have to be respected,** as the organisation of the sequences is left to your discretion and may depend on other factors (e.g. availability of an expert trainer; timing of the training sequences; space reserved for exercises...).

In some cases, **only certain aspects** (or chapters) of the **subject will be covered** (for example: if the participants have a perfect command of certain parts of the subject covered in the training, it is not necessary to present them in detail; a small reminder may be sufficient and effective to cover the rest).

However, when you cover part of the material (a chapter), the main 'points' listed for each chapter allow you to organise your presentations and animations in a logical and relevant way for the learner. **You are also advised to present all the points of a chapter.**

2. Training leaflets

A Training Notebook contains as many 'leaflets' as there are chapters in the training manual (only the 'case study' is not included). Each sheet contains, on the one hand, the **Training objectives** of this part of the subject to be delivered (what the learner must be able to deliver...), and on the other hand, according to the structure of the table, the 'key messages' (what the learner must absolutely have assimilated at the end of the training). It is therefore very important to ensure that **all messages are well distributed during the training sequence.**

3. A summary of the content of the manual

A summary of the manual has been included in this Training Notebook. Structured in the same way as the manual, it contains most of the content in 15-20 pages but remains much less complete (the summary does not include figures or case studies).

This summary is **primarily intended for the trainer.**

- **At the beginning of the mission**, when preparing its intervention sequences and supports, it allows you to quickly become familiar with all the content you will need to address and to visualize the links between the different parts of the material to be delivered.
- **During the training,** you can use this summary **to prepare your daily summaries,** reminding participants of the essential elements seen during a day (15-20 minute summary at the end of the day with answers to questions).
- **At the beginning or end of the training,** if you wish, you can give participants a copy of this summary. If the summary is distributed at the beginning of the training, it is advisable to ask participants to highlight the passages mentioned in your end-of-day summary (benchmarks in the subject).

The summary is also useful for learners at the end of the course: it will allow them to **remember in a** few minutes the **main part of the topic covered** (for example, before an assessment of prior learning), whereas reading the entire manual could be tedious.

HOW CAN THIS TRAINING NOTEBOOK HELP YOU PREPARE YOUR TRAINING INTERVENTIONS?

The intention of making this Training Notebook available to you is to **help you prepare your training sequences and structure your program day by day.**

- **Consider that each leaflet represents a whole:** if there are for example 4 leaflets, it means that there must be 4 distinct parts in your training. Sufficient time must therefore be allowed in the programme for each of these 4 parts. Each part of the subject will also have to be subject to a competency assessment.
- **Then consider the training objectives:** this will help you to choose: (a) the most appropriate training method for achieving your objectives (e.g. should you plan exercises, simulations, group activities etc.); (b) the method for evaluating the learning acquired in this part.
- **Finally, prepare your materials** (e.g. PowerPoint, flipcharts or animation sheets, evaluation questions) by ensuring that all key messages are included ("Have I planned to discuss all these points? Have I planned an evaluation on each key point?").

DON'T FORGET TO COMPLETE THIS TRAINING NOTEBOOK!

This Training Notebook is made **for you**... It is **a tool that must live!**

At the end of each leaflet, a space was left free to add your personal notes: as a trainer you can note some thoughts on how to get messages across, note your questions, participants' reactions, points that raise difficulties... *i.e.* **capitalise on your experience as a trainer!**

You can also **note the types of media you have used.** This will be very useful when you have a new session to facilitate on the same theme. COLEACP provides you with many tools and materials, but do not hesitate to create others or use other existing materials that may be available... the **rule is to master each of the materials used in training** and to ensure that they help to convey key messages more effectively than in their absence.

Materials to be delivered

CHAPTER 1 – ENERGY SOURCES, ENERGY MANAGEMENT SYSTEM AND ENERGY AUDIT

- Introduction
- Energy needs and basic principles of energy economics
- Energy management systems
- Energy audit

CHAPTER 2 – EFFICIENT USE OF ENERGY, RATIONALISATION OPTIONS, ENERGY BALANCE

- Access to energy
- Energy efficiency
- Understand how to limit energy consumption on a farm/company

CHAPTER 3 – ENERGY TRANSITION, RENEWABLE ENERGY MANAGEMENT AND PRODUCTION TECHNIQUES

- Energy transition
- Assessment tools to assist in decision-making
- Decentralised renewable energies for storage, processing, transport and post-harvest distribution

Training leaflets

LEAFLET 1

Energy sources, energy management system and energy audit

TRAINING OBJECTIVES

At the end of this training sequence, the participant must be able to:

- understand the energy issues related to agricultural production, and, more generally, related to climate change;
- understand energy issues in an agricultural SME;
- identify the elements of energy consumption on a farm and the sources of this energy;
- understand the requirements of an energy audit.

KEY MESSAGES

1) Energy issues related to agricultural production and climate change

- The agricultural sector must transform itself to feed a growing world population, but the impact of climate change makes this task more difficult.
- The agricultural sector is one of the major consumers of direct energy (fuel, gas for heating livestock buildings, electricity) and indirect energy (fertilisers, food etc.).
- Energy services are needed to meet basic human needs and to ensure production processes.
- Climate change is affecting the ability of the agricultural sector to ensure food security for local populations.
- The food system accounts for about 30% of total global energy consumption with 38% of the energy consumed in the agri-food chain.
- Most of the energy used comes from fossil fuels, which are among the largest contributors to greenhouse gas (GHG) emissions.
- There is a real and urgent need for all those involved in agri-food chains to become more efficient in their energy consumption.
- The agricultural sector must adapt towards energy efficiency to ensure sustainability as well as socio-economic and environmental viability.
- Farmers are not only the actors of food self-sufficiency, but they can also be major actors in energy self-sufficiency.
- Reducing GHG emissions, while meeting global demand for energy services, requires efficient energy conservation and fossil fuel switching.
- Both agricultural holdings and the energy sector must allow the development of renewable energies in two ways: in terms of energy production (recovery of agricultural residues) and in terms of the use of renewable energies on farms.

2) Energy issues in an agricultural SME

- Agricultural SMEs are highly dependent on fossil fuels and adaptation. Therefore, their judicious selection of energy technologies that maintain production and other activities is a high added value.
- The preferred option of an agricultural SME is that of renewable energies (RE) properly implemented to offer a high potential for co-benefits.
- Investing in renewable energies means preserving the energy of the SME.
- The SME must carry out an 'inventory' to serve as a 'zero point' of the action plan before developing new technologies and/or investing in new technologies.
- SMEs must introduce modern energy services into agricultural activities, including 'climate-smart agriculture' (CSA).
- Climate-smart agriculture contributes to sustainably increasing productivity, adapting to and building resilience to climate change, as part of the reduction of GHG emissions.
- The co-benefits of moving from fossil fuel dependency to RE help in climate change adaptation, not only for SMEs, but also to reduce the cumulative impact of GHG emissions in their region.
- SMEs must move towards (agri)food systems that improve energy efficiency and increase the use and production of renewable energy.
- Energy-efficient food systems increase access to modern energy services.
- The synergy between climate-smart agriculture and energy-efficient food systems creates added value for SMEs: reduced emissions and dependence on fossil fuels; and improved productivity and resilience of agro-ecosystems

3) Sources of consumable energy on a farm

- Fossil fuels include oil, coal and natural gas.
- They are all carbon-rich fuels, mainly hydrocarbons derived from the methanisation of living beings that have been dead and buried in the ground for several million years.
- Fossil fuels are responsible for high GHG emissions.
- Used alone, fossil fuels are generally not recognised as providing co-benefits.
- Renewable energy sources are wind, solar, hydroelectric, geothermal or biomass resources.
- Wind energy is a wind-dependent energy source. This energy is used to produce electricity in wind turbines thanks to the force of the wind.
- Solar energy is a source of energy that depends on the sun and allows electricity to be produced from photovoltaic panels or solar thermal power plants, thanks to sunlight captured by solar panels.
- Hydroelectric production is the process of transforming the potential energy of water into electrical energy.
- Geothermal energy depends on the Earth's heat and makes it possible to produce electricity in geothermal power plants using very hot water from underground aquifers.
- Biomass energy is a renewable energy source that depends on the cycle of living plant and animal matter.

- RE technologies are widely used in CSAs and intelligent energy systems.
- The combination of appropriate energy technologies, equipment and facilities can improve energy efficiency and reduce GHG emissions.
- Determining the combination of energy types that offers the best benefits requires study, cost calculation and good investment planning.

4) The requirements and the performance of an energy audit

- An energy management system encompasses all the elements of an organisation that are necessary to create an energy policy.
- An energy audit is a study of how energy is used in an installation and an analysis of possible alternatives.
- An energy audit is a key element of the ISO 50001/2 standard and helps to evaluate the effectiveness of the implemented energy management system.
- An energy audit (or review) requires independence, a definition of what is being sought, a working methodology, analysis of results and a report.
- The audit approach includes: planning, definition of responsibilities, identification of the main systems to be considered, definition of scope and limits, site visits, audit report.
- Planning is done by developing a questionnaire to obtain data and all information on production and construction with facilities and operating system.
- The definition of responsibilities and deadlines makes it possible to carry out verification/revision.
- Observation makes it possible to identify the main energy systems, and also check human safety behavior when using the equipment.
- The definition of the range and limits allows each limit to be segmented according to significant energy use.
- Site visits make it possible to inventory energy production and production equipment.
- Meetings are used to establish the objectives and targets of the audit/review.

5) Identify the elements of energy consumption on a farm

- A detailed inventory of all lighting must be produced: type of luminaires and lamps, lamp wattage and hours of operation.
- A detailed list of all heating, cooling and ventilation equipment must be recorded in the inventory with: size, model number, electrical specifications and estimated hours of use.
- A detailed inventory of electric motors must be produced: motor size, use, age, model, estimated operating hours, electrical characteristics and possible integration of the variable speed drive.
- Look for any piece of equipment with a power supply that is rarely used or whose use could be controlled or moved to off-peak hours.
- Explore recovery options for preheating the residual heat typically generated from the system exhaust.
- Inspect stream line to identify any leaks or insulation failures.

PERSONAL NOTES AND REFERENCES OF THE MATERIALS USED

LEAFLET 2

Efficient use of energy, rationalisation methods, energy balance

TRAINING OBJECTIVES

At the end of this training sequence, the participant must be able to:

- identify where consumption reduction is possible;
- understand how to limit energy consumption on a farm, a company;
- understand how to undertake an energy balance;
- quantify fertilisers inputs and outputs at the farm level.

KEY MESSAGES

1) Look for points in the process where consumption reduction is possible

- Production, harvesting and post-harvest are the different stages where energy inputs are made and consumption can be reduced.
- In production, less use of pesticides and chemical fertilisers means less energy required for production and pollution control, at the SME or the community level.
- In production, fungicide sprays for fresh produce can be carried out using simple hand pumps.
- At the harvest stage, working early in the morning when air temperatures are cooler reduces energy requirements and cooling costs.
- Using low-tech methods for drying, cleaning or washing, disease and pest control, sorting, grading and packaging is less energy consuming.
- For sorting and grading, grading rings and color charts are used to visually sort and manually sort fresh fruit and vegetables.
- Simple tools such as rulers or stirrups are used to measure the size or length of products.
- Packaging can be done by hand in locally manufactured plastic crates, cardboard boxes or containers lined with plastic bags.
- Natural air ventilation can be promoted: thermal chimneys are added to existing structures or included in the design of new facilities to ensure natural cooling of the packaging station environment.
- Solar energy and biodiesel (eco-energies) are used in irrigation and greenhouses, for cooling and transport.
- Agricultural production patterns influence energy consumption, and organic farms offer opportunities for indirect energy savings (fewer inputs).
- High efficiency heating systems offer an ideal solution for heating while protecting the environment and saving energy and money.

2) Energy efficiency, conversion, and minimisation and maximisation strategies

- Efficiency always involves both the resources used and the services provided.
- Efficiency involves a change in the system in which power and heat are generated in a conventional way in production cycles.
- Instead of conventional systems, heat reuse/recovery systems and cogeneration installations are recommended.
- High efficiency lighting is an energy-efficient option, such as light-emitting diode (LED).
- The total efficiency of the luminaire is defined by the ratio between the flow out of the luminaire and the power consumption.
- In water pumping systems, simple but relevant solar-powered irrigation kits are energy efficient and allow energy savings.
- Variable speed drives eliminate on/off sequences, thus reducing energy consumption and noise levels, while sparing the motors to increase their service life through soft start.
- Variable speed drives improve the energy performance of installations by adapting the cold power to the strict necessity of demand and reduce peak intensities in electricity consumption.
- High efficiency compressors are installations that reduce the energy consumption of the compressed air system.
- Heat recovery units are kits added to the furnace to better distribute the heat produced so that the entire house benefits from a single heat source; it is a proven and effective energy-saving measure.
- Pre-coolers are heat exchange systems, between (for example) milk and cold water, that allow a pre-cooling product to be sent into the tank.
- Professional (or self-made) audits are useful and even necessary for the continuous improvement of the company.

3) Approach to limit energy consumption on a farm, a company

- The first challenge in limiting energy consumption on a farm or a company is to define the boundaries of the energy system and facilities.
- The definition consists of defining a system boundary in a very specific way.
- The definition applied to the ‘system’ is: any building consuming energy, an area within a building, an operating system, a collection of equipment or a piece of equipment around which a boundary can be placed in a figurative sense.
- The energy flows crossing the border must be taken into account in order to be able to quantify the emitted and outgoing flows.
- The second challenge is the collection of energy flow data from various sources, including direct measurements, considering only those energy flows that cross the system boundary as defined.
- The third challenge concerns raising awareness and informing employees about the company’s energy policy with energy management objectives and individual responsibilities.
- A transparent energy management plan must be available to all.

4) Undertake an energy balance

- An energy balance is a consideration of the contribution, production and consumption of energy in a particular stage of a process.
- It is necessary to make a list of all energy inputs in order to know the real cost of energy consumption through the analysis of the data collected.
- A complete calculation of the amount of energy per piece of equipment is mandatory for a realistic and reliable balance.
- Specific energy performance indicators are essential for a better assessment of a company's energy consumption.
- The drafting of an energy action plan is carried out in order to allow each department concerned to determine its potential savings.
- The formulation of specific energy objectives and the monitoring of energy consumption are carried out on the basis of the identified improvement opportunities.

5) Quantification of energy inputs and outputs at farm level

- It is necessary to select practical units of measurement and be able to convert the different units into a single unit selected for data consolidation.
- It is necessary to know how to calculate the energy contained in the volume of material, the mass flows and the heat produced from the different forms of energy of the precursors.
- It is important to distinguish consumers according to their energy usage.
- The most important energy uses, their nominal power, operating hours and consumption are listed to calculate the 'energy performance indicators' (EnPIs) (put the data in Excel tables).
- Data entry is facilitated by Excel: tables provide lists for the most common applications.
- The two major EnPIs are: energy consumption in relation to production (in kWh/tonne) and energy costs in relation to production (in $ or €/tonne).

PERSONAL NOTES AND REFERENCES OF THE MATERIALS USED

LEAFLET 3

Energy transition, renewable energy management and production techniques

TRAINING OBJECTIVES

At the end of this training sequence, the participant must be able to:

- know the principle of the energy transition;
- know the different types of technologies available in renewable energy;
- know the tools available for decision-making and how to use them;
- make choices, advise operators on the type of technology to adopt in order to reduce energy consumption.

KEY MESSAGES

1) The principle of the energy transition

- The energy transition refers to the renunciation of certain traditional energies in favour of a more sustainable production and consumption model in the face of social, economic and environmental challenges.
- The energy transition means defining common objectives to succeed, strengthen energy independence, preserve health and the environment, and fight global warming.
- The principle of energy transition is based on the fight against waste and the promotion of the circular economy: from product design to recycling, procedures must be simplified and clarified to improve efficiency and competitiveness.
- To ensure a successful energy transition, citizens, businesses, territories and the State must be empowered to act together.
- The energy transition is about producing and consuming better without polluting (such as power plants that burn fossil fuels, such as coal or natural gas).
- For the energy transition, a good working knowledge of the local resources available is necessary so that an appropriate energy system can be selected.
- To live and produce with an appropriate RE, or the optimal combination of energy sources, investments and adaptations must necessarily take place.

2) The different types of technologies available in renewable energy

- The most frequently used renewable energy technologies in the energy transition are: hydropower, wind power and energy derived from biomass or bioenergy.
- Solar, geothermal and tidal energy are the most readily available and frequently used renewable energy technologies.
- Hydroelectricity is powered by water, so it is a clean source of energy.

- The main principle behind wind energy is the transformation of wind flows into rotational movements.
- Next-generation bioenergy is produced from a variety of biomass materials (cultivated, agricultural and forestry residues and other cellulosic materials).
- Solar energy is a natural form of energy that is produced from heat and light derived from the sun.
- Geothermal energy is the heat from the Earth that can be used to heat or produce electricity.
- Tidal energy comes from the movements of water created by the tides and caused by the combined effect of the gravitational forces of the Moon and the Sun.

3) The tools available for decision-making and how to use them

- Decision-making begins with considering what the renewable energy system will provide in relation to the required energy production.
- Agricultural operations must be considered in the choice of available renewable technologies.
- When planning the investment, a feasibility analysis must be carried out, a tool that will determine whether or not the project can be completed.
- The first step in the feasibility analysis is to contextualise the investment in an economic, institutional, social and technical framework.
- During the feasibility analysis, a preliminary test of the value of the investment must be carried out.
- A preliminary test of the value of the investment requires a clear identification of financial, economic, institutional, social and technical opportunities and risks.
- The technical analysis of the tools is carried out in several stages: awareness/training, cost/benefit assessment and adoption according to local realities.
- During the technical analysis, the adoption of the technology option also depends on the risk perceived by the company or the farmer and stakeholders.
- The comparative analysis allows the identification and as well as the description of the baseline and post-energy intervention scenario, investment results and the determination of additional net flows.
- The identification and description of the reference scenario consists of describing fossil fuel technologies and/or inefficient technologies.
- The identification and description of the post-energy intervention scenario concerns the technology adopted.
- The identification of investment results takes into account investment and operating costs, and monetary benefits.
- The additional net flows in the comparative analysis represent the financial and/or economic flows of the project.
- Business models and the business ecosystem is are continuous improvement tools that allow the company or the farmer to evolve in performance.

4) Choice and advice on technologies to adopt to reduce energy consumption

- Before any investment is made, it is necessary to make an inventory of the different possible REs and to evaluate the different technologies existing in the area of activity.
- There are different technologies for the same RE, and a combination of different REs can be adopted to perform the same activity.
- A comparative cost/benefit study of each technology should be conducted based on the type of RE identified.
- Depending on the size and type of activity being carried out, appropriate, effective and efficient technology must be selected.

PERSONAL NOTES AND REFERENCES OF THE MATERIALS USED

Summary of the manual

Sustainable energy management

1. THE CHALLENGES OF CLIMATE CHANGE FOR THE AGRICULTURAL SECTOR

The agricultural sector faces challenges at different levels, mainly related to the effects of **climate change.** These climate changes, caused by human activities, have **affected the availability of** adequate **natural resources** and the quality of the atmosphere, soil and water. Never before have farmers had to rely so much on 'innovation' and 'creativity' to survive in local, regional, national or global markets, and to cope with unprecedented pressure on the planet's life support systems. In short, climate change is affecting the ability of the agricultural sector to ensure food security for local populations. The most affected sectors appear to be agriculture and agricultural enterprises in countries heavily dependent on agricultural inputs as a proportion of GDP. These countries, which include ACP countries, are particularly vulnerable to the effects of climate change and the additional pressure of expanding populations. Predictions suggest that, by 2050, the world's population will increase by a third and that a large proportion of these additional people will live in countries with low GDP.

FAO (2013) estimates that agricultural production will have to increase by 60% by 2050 to meet expected food demand as current trends in income and consumption growth continue. Therefore, the **agricultural sector must really transform itself** to feed a growing world population, to lay the foundations for continued economic growth and to reduce poverty in countries with lower GDPs. Unfortunately, the **impact of climate change will make this task much more difficult** in a business-as-usual scenario, due to the negative impacts on agriculture and the increasing costs required to address these impacts.

2. MAIN ENERGY CHALLENGES

The cumulative impact of changing food consumption patterns is directly related to **economic growth**, increased consumption capacity, the emergence of new technologies, demographic changes, lifestyles and the impacts of climate change (OECD, 2017). The Intergovernmental Panel on Climate Change (IPCC) recommended that to mitigate the effects of climate change we should **increase energy efficiency in the short term.** FAO (2011) states that globally, the food system accounts for about 30% of total global energy consumption and more than 70% is consumed beyond the farm gate, producing about one fifth of global greenhouse gas (GHG) emissions. Much more alarming is the fact that more than a **third of food production is lost or wasted,** and with it about 38% of the energy consumed in the agri-food chain.

Currently, most of the energy used comes from **fossil fuels,** which have proven to be among the largest contributors to GHG emissions. There is therefore a real and urgent need for all those involved in agri-food chains to **become more efficient in their energy consumption.** Energy efficiency can bring a triple gain:

- a protected and preserved environment;
- an improving socio-economic situation in a sustainable development;
- ensuring the sustainability and economic viability of the contributions of small and large business owners.

At the level of agri-food chains, adaptation includes the **judicious selection of energy technologies** that maintain production and other value-added activities for agri-food chains.

3. INTERACTION BETWEEN CLIMATE CHANGE AND THE USE OF RENEWABLE ENERGY TECHNOLOGIES

Data collected over the past decades confirm that fossil fuel consumption accounts for the majority of global anthropogenic GHG emissions. As a result, CO_2 concentrations had increased to over 390 ppm, 39% higher than pre-industrial levels, by the end of 2010. Fortunately, several options can be applied to help reduce GHG emissions from the energy system while meeting global demand for energy services. These include, among others:

- energy conservation and efficiency;
- switching fossil fuels, for example from coal to natural gas, and RE (renewable energy).

Climate-smart Agriculture (CSA)

Climate change is already having a significant impact on agriculture and food security due to the increased prevalence of extreme weather events and the emerging unpredictability of weather patterns. Smart agriculture for climate (ASC), as defined and presented by FAO to The Hague Conference on agriculture, food security and climate change in 2010, contributes to the achievement of sustainable development objectives. **CSA integrates the three dimensions of sustainable development** (economic, social and environmental) by jointly addressing food security and climate challenges. It is composed of **three main pillars:**

- increase agricultural productivity and income in a sustainable way;
- adapt and strengthen resilience to climate change;
- reduce and/or eliminate GHG emissions.

The co-benefits of this shift from fossil fuel dependence to RE help to adapt to climate change by reducing the cumulative impact of GHG emissions.

Intelligent energy supply systems

The way forward for those who produce and those who process 'beyond' the farm is to move towards energy-efficient food systems. These systems improve energy efficiency, increase the use and production of renewable energy and expand access to modern energy services in agri-food chains. According to FAO, intelligent energy supply systems should address the following issues:

- the energy needed to ensure food security;
- CSA-related technologies;
- energy poverty in rural development;
- the contribution to the development of green and inclusive food value;
- contributing to secure access to sustainable energy in emergency and/or rehabilitation contexts.

All these aspirations lead nowhere unless all countries can guarantee farmers and other actors in the agri-food chain access to sustainable energy, which is the aspiration of the United Nations SE4All initiative.

Sustainable Energy for All – SE4All

The global energy transition needs the objectives of the SE4All initiative, which are as follows:

- a rapid increase in energy productivity;
- a new generation of institutions to manage our energy systems;
- an integrated approach to energy that includes both centralised and decentralised sources;
- an ever-increasing share of renewable energies in the mix.

The energy transition must be a 'just' transition, all stakeholders must be taken into account, no one should be left behind.

4. ENERGY SOURCES

By definition, fossil fuels are formed by natural processes, such as the anaerobic decomposition of buried dead organisms, containing energy from ancient photosynthesis. Used alone, fossil fuels are generally not recognised as providing co-benefits.

Unlike fossil fuels, which are responsible for high GHG emissions, renewable energy technologies often widely used in CSAs and smart energy systems tend to be adapted from wind, solar, hydroelectric, geothermal and biomass resources.

The combination of appropriate energy technologies, equipment and facilities improves energy efficiency, reduces GHG emissions and contributes to food security. Before making decisions about the appropriate types of energy mixes, it is important to study the situation, calculate costs and plan the actions to determine whether the selected combination of energy types offers more advantages than disadvantages.

5. ENERGY NEEDS AND BASIC ENERGY SAVING

Financial and economic analysis is more an art than a science for the economics of energy management. In general, energy management, with short payback periods, does not always require sophisticated evaluation. Depending on the size of the company and the purpose of the proposed investment, there are three types of methods commonly used to determine the benefits in relation to the costs of investments in energy technologies:

- cost-Benefits Analysis (CBA);
- life Cycle Cost Assessment (LCCA);
- life Cycle Assessment (LCA).

6. ENERGY EFFICIENCY AND CHOICE OF ENERGY SOURCE

Existing production and processing practices on and off the farm can be adapted to consume less energy and at the same time provide food in a safe and environmentally friendly way.

RE technologies are preferred over fossil fuels despite the fact that start-up costs are generally higher than those of fossil fuels; not only because GHG emissions are lower, but also because the cost of most renewable energy technologies continues to decline.

Energy management systems – ISO 50001 and ISO 50002

ISO 50001/50002 is the energy management system standard that specifies the requirements for establishing, implementing, maintaining and improving an Energy Management System (EnMS). Its objective is to enable an organisation to continuously improve its energy performance, including aspects of energy efficiency, energy security, energy consumption and consumption.

The term 'energy management' means many different things to different people. As a general rule, it involves the application of at least three principles:

- purchasing the energy supply mix at the lowest possible price per unit of useful energy production;
- management of energy conversion and maximum efficiency consumption;
- using of the most appropriate technology.

The Plan-Do-Check-Act cycle (PDCA)

ISO 50001/50002 standards are based on the PDCA (Plan-Do-Check-Act) cycle. PDCA is a four-step iterative management method used in companies for the control and continuous improvement of processes and products.

Energy audit

An energy review is a study of how energy is used in a facility and an analysis of alternatives that could be used to reduce energy costs. There are two types of energy tests.

- Passage audit: a visual inspection of the facility is carried out to identify energy-saving opportunities related to maintenance and operation, as well as data collection to determine the need for more detailed analysis.
- Full audit: requires tests and measurements to quantify energy uses and losses, determine the economics of changes and further evaluate the amount of energy used for each function.

An energy audit is divided into several stages:

- planning ;
- defining responsibilities and deadlines, organise a meeting;
- defining of the scope and limits according to a significant use of energy, the production line or the distribution network;
- site visits to inventory specific energy production and production equipment;
- consideration of the main systems: building envelope, heating/ventilation/air conditioning (HVAC) system, power supply system, etc.

7. EFFICIENT USE OF ENERGY, RATIONALISATION METHODS, ENERGY BALANCE

The evolution of agriculture or a modern agricultural enterprise is ccharacterised by higher and higher use of energy inputs to increase productivity. In the context of efficient energy use, it is essential to analyse the ways of rationalising energy consumption in these agricultural businesses. Indeed, the energy necessary for the energy balance of the human body is obtained by man from his food.

This food is produced by agriculture, which is therefore a source of energy. Just as human food corresponds to an energy system, agriculture is also characterised by an energy input and output. The energy balance of agricultural businesses, like human activity, consumes energy for its means of production. Energy consumption assessment is the first step towards improving energy management. Rationalisation can be considered after analysing energy availability and costs, ways to reduce energy consumption, and the economic and environmental gains generated.

8. ACCESS TO ENERGY

Agricultural businesses use energy both directly as fuel (gasoline, diesel, natural gas), electricity and, indirectly, by using energy-intensive inputs such as fertilisers and pesticides.

As energy is at the heart of all agricultural operations, **it is essential that farmers and businesses adopt new ideas to use energy efficiently and effectively.** And, like any modern company, the farmer or company can benefit from this concept by reducing operating costs, minimising risks, or even generating additional income by selling excess energy on site.

Efficient energy use not only benefits the global community in the form of co-benefits and food security, but efficiency in energy use can also:

- obstruct or support regional development plans;
- make or break up farming communities.

However, the current reality is that most small landowners and businesses in many ACP countries sometimes have limited access to energy with occasionally volatile prices. This energy availability has a global impact on the sustainability of an agri-food chain or farm business. CARICOM Member States are mainly importers of fossil fuels (hydrocarbon producers or not and other energy producers). Overall, CARICOM Member States are not major players in global markets, and are therefore hostage to the vagaries of international supply and fossil fuel pricing. The majority of Pacific Small Island States (SIDS) depend almost exclusively on imported refined petroleum products to meet their energy and transport energy needs. The African continent and African ACP countries have local supplies of fossil fuels that are traded on an intra-regional basis. However, despite the abundance of fossil fuel supplies in some regions, many countries remain net importers of energy.

In any case, the challenges are related to the low security of energy supply, energy poverty at various levels and the urgent need to reduce the regional carbon footprint in order to improve the climate compatibility of the energy sector.

9. POINTS WHERE CONSUMPTION REDUCTION IS POSSIBLE

Processing, post-harvest systems, storage and cooling are considered energy-intensive steps in agri-food chains or agricultural businesses that rely on conventional energy derived from fossil fuels. All these activities in food production systems are necessary to transform raw food products into consumer products for local, national and export markets. These activities require direct and indirect energy inputs.

- Direct energy inputs: petroleum fuels for tractors and other machinery, irrigation installations, electricity for engines, lighting, refrigeration and natural gas for water heating.

- Indirect energy inputs include those used for the manufacture and delivery of fertilisers and agrochemicals except what is absorbed into farm buildings, machinery, factories and transportation.

Then, the different stages where energy inputs reveal points of possible reduction in consumption are at the level of:

- the production stage: use of simple hand pumps for phytosanitary treatments, perforated trays and drainage basins;
- the harvesting stage: work during the cold periods of the day and use low-tech solutions for drying and cleaning operations;
- the post-harvest stage: encourage more manual work for cleaning, sorting, grading and packaging;
- natural ventilation is a point of reduction in energy consumption in agricultural businesses.

Energy efficiency

Globally, the exponential increase in energy consumption by the agricultural sector has made most farmers and other agricultural stakeholders vulnerable to high energy costs and volatile market fluctuations. Yet, if implemented effectively, energy efficiency measures can help agricultural producers reduce the amount of energy they use without compromising productivity and at the same time reducing their energy costs. This will allow them to be less vulnerable and contribute to more local economies.

In fact, there are many opportunities for direct energy savings in agricultural businesses by integrating RE technologies into energy systems. This integration takes place in many operational areas, including high efficiency ventilation systems, variable speed drives, high efficiency compressors, heat recovery units, pre-coolers, high efficiency lighting and high efficiency heating systems.

Other opportunities for indirect energy savings can be found in the form of organic farms, which consume much less fossil energy than their conventional counterparts. Organic farms offer triple benefits to businesses and farming communities:

- better nutritional quality of products;
- reduced groundwater pollution, helps to minimise water absorption (through tillage and mulching) and maintains water quality;
- reduced pesticide use, which contributes to the preservation of biodiversity, reduces pesticide residues and reduces workers' exposure to pesticides, reduces total operational costs and profitability.

Minimisation and maximisation strategies – Approach

In thermal power plants, energy input refers to the heat introduced into the process and the electricity obtained as a useful output.

Both elements are energy flows and can be quantified using thermodynamic calculations that result in an absolute value of efficiency. It is therefore recommended that producers and contractors **always carry out an energy audit.** Once the results and recommendations of the energy audit are available, farmers or companies may choose to adopt strategies commonly known as maximisation or minimisation to improve overall energy efficiency. Efficiency always involves both the resources used and the services provided.

Efficiency is considered to have been improved if:

- with the same resource consumption, we obtain a better service than before, it is the maximisation strategy; or if,
- for the same service provided, fewer resources are used, this is the minimisation strategy.

The **first challenge** in limiting energy consumption on a farm or a company is to define the boundaries of the energy system and facilities, which consists of defining a system boundary in a very specific way. This definition applied to the 'system' is any energy-consuming building, an area within a building, an operating system, an equipment collection or a piece of equipment around which a boundary can be placed in a figurative sense. The energy flows crossing the border must be taken into account in order to be able to quantify the emitted and outgoing flows.

The **second challenge** is the collection of energy flow data from various sources, including direct measurements and considering only those energy flows that cross the system boundary as defined.

Finally, the **third challenge** will lead the farmer or agricultural entrepreneur to carry out an awareness/information program for employees on the company's energy policy with the objectives of energy management and the responsibilities of each.

To improve energy efficiency, **it is also important to identify areas where energy consumption can be reduced.** Certain measures must be taken to achieve energy efficiency, including:

- regular reviews of energy consumption with attention to past energy bills or fuel consumption patterns;
- undertake site evaluations to record equipment used and performance data;
- carry out a technical and cost analysis; for the technical analysis, a simple energy balance can be carried out;
- develop action plans to identify energy efficiency measures that can be taken to improve energy costs and savings.

10. UNDERTAKE AN ENERGY BALANCE IN A FARM BUSINESS

The agricultural company must first develop an energy baseline built on energy performance indicators to be integrated into energy management systems or to assist in energy audits.

The energy baseline is a summary of the total energy use defined for the reference period and the production parameters of the baseline. The farm business will have appropriate **energy performance indicators (EnPIs)** to monitor and measure the energy performance of the system.

Energy baseline

Changes in energy performance are measured against the original reference values. Baselines must be adjusted for one or more of the following:

- energy performance indicators no longer reflect the organisation's energy use and consumption;
- major changes have been made to the process, operational models or energy systems;
- according to a predetermined method as defined in the procedure.

Energy performance indicators

The methodology for determining and updating EnPIs is established in the energy management system procedures and records maintained. EnPIs are regularly reviewed and compared with the energy reference database, where applicable. Indicators should **preferably comply with the requirements of ISO 50001** to allow internal and external comparison and benchmarking.

The different types of indicators (EnPIs) used are as follows.

- Indicators based on operational data (advance and delay): energy performance is generally assessed with 'delayed indicators' which are retrospective measures based on actual operational data, reflecting the 'before' situation of energy performance.
- Operational level indicators: these indicators are generally relatively simple process functions calculated on a semi or fully continuous basis to measure and monitor energy consumption in the short term, up to a single unit or facility.
- Site-level indicators: these indicators are based on aggregate site data and are generally calculated on a quarterly or annual basis. They are used to measure and monitor the energy efficiency of the site over time and/or by peers. Site level indicators measure absolute energy consumption and specific energy consumption. As a result, each operating area has its own structural energy consumption that reflects the specific tasks it performs.

If all the information collected by this process, the farmer and/or the agricultural entrepreneur will be able to **carry out the company's balance sheet**. An energy balance is a consideration of the energy input, production and consumption in a process or stage. Specific energy performance indicators are essential for a better assessment of a company's energy consumption. To carry out his energy balance, the farmer and/or agricultural entrepreneur will take into account:

- the list of all energy inputs in order to know the real cost of energy consumption through the analysis of the data collected;
- the exhaustive calculation of the quantity of energy per equipment that is mandatory for a realistic and reliable balance;
- the drafting of an energy action plan to enable each department to determine its savings potential;
- the formulation of specific energy objectives and the monitoring of energy consumption that are carried out on the basis of the identified improvement opportunities.

11. THE ENERGY TRANSITION

The energy transition refers to the shift from certain traditional energies to a more sustainable production and consumption model that addresses socio-economic and environmental issues. Its ecological objective is to change the current energy system towards a new energy system based on renewable resources.

Two factors have an impact on the energy consumption of actors of all sizes involved in agri-food chains. The first is to understand how agricultural businesses use energy directly in the form of fuel (gasoline, diesel, natural gas) and electricity and, indirectly, by using energy-intensive inputs. The second factor is to adopt new ideas that aim to use energy efficiently for several reasons known as co-benefits:

- reduce GHG emissions;

- ensure long-term food security;
- reduce operating costs and increase profits.

Before these co-benefits are realised, an energy transition, *i.e.* a **long-term structural change in an energy system, must take place.** This implies **reducing independence from fossil fuels,** energy production costs and environmental impact by initiating an energy transition process based on appropriate, suitable and available technologies.

Current use of renewable energy resources in the agri-food sector in ACP countries

In most ACP countries, agriculture and related agri-food activities are at the heart of rural economies. Although the integration of land use for agriculture and energy is increasing, investment costs remain high.

Lack of financing, remoteness of energy demand, including access to electricity and gas networks, competition for land use and transport constraints are obstacles to the implementation of new appropriate technologies. Water supply limitations as well as the lack of skills and knowledge on the part of landowners or managers influence how to make an energy transition. To address this challenge, various policy and governance initiatives have been put in place in the Caribbean and Pacific to address this situation.

In addition, the **ACP-EU Energy Facility** has played a key role in financing political and governance initiatives across the African continent. These actions help to introduce RE technologies in rural areas. The aim is to boost agricultural productivity, reduce food losses and imports, eliminate malnutrition and increase resilience to climate variability. The ACP-EU Energy Facility has promoted access to energy services in rural and peri-urban areas, and has improved energy governance and capacity development in African ACP countries through different organisations.

- The West African Power Pool (WAPP) which is a specialised agency under the Economic Community of West African States (ECOWAS).
- The CAPP (Central African Power Pool), a specialised body of ECCAS (Economic Community of Central African States), in charge of the implementation and coordination of energy policy, infrastructure expansion, as well as the establishment of legal, technical and commercial conditions, to increase investment and electricity exchanges in the sub-region.
- Membership of the East African Power Pool (EAPP) includes public services and/or concessionaires and/or companies in charge of electricity production, transmission and/or distribution in East African countries.
- The Southern African Power Pool (SAPP), the priority actions funded by the Energy Facility for SAPP are mainly capacity building for network operations, system planning and the promotion of public-private partnerships.

It should be noted that the **purpose of the international standard ISO/IEC-13273 is to provide support for energy activities related** to energy efficiency and renewable energy sources. It is a horizontal standard in accordance with IEC 108 Guide. It covers the fundamental principles and terminology concepts in the fields of energy efficiency and energy management. These principles and concepts are relevant for different technical committees, whose purpose is to promote consistency and the establishment of common characteristics of energy terms. This standard is more appropriate for regulatory bodies involved in the development of standards for energy efficiency and renewable energy sources.

The principle of the energy transition and the benefits associated with an energy transition

An energy transition defines common objectives to succeed : strengthen energy independence, preserve health and the environment and fight global warming. The principle of the energy transition is based on the fight against waste and the promotion of the circular economy: from product design to recycling, simplify and clarify procedures to improve efficiency and competitiveness.

The energy transition could not only help reduce GHG emissions and energy losses, but also help individual companies to:

- develop their operations in a sustainable way;
- improve both their own health and that of their employees;
- help generate local employment opportunities.

12. RENEWABLE ENERGY TECHNOLOGIES FOR AGRI-FOOD CHAINS

The farmer or business owner must be able to choose the appropriate renewable energy source, or the optimal mix of sources. The type of preferred energy source will always depend on the resources available on the site and the financial investment associated with this type of energy transition. The technologies used to exploit renewable energy resources and convert them into useful forms of energy are called renewable energy technologies. For farmers, **there are several technological solutions** for RE that can be integrated into the agricultural process.

This can lead to better energy efficiency, lower environmental impact and lower production costs. Some of the most readily available and frequently used RE technologies are:

- hydroelectricity, renewable electrical energy that comes from the conversion of hydraulic energy into electricity;
- wind energy, an energy source that depends on the wind;
- energy derived from biomass or bioenergy, energy derived from the conversion of solar energy into biomass by biological processes;
- solar energy, an energy source that depends on the sun;
- geothermal energy is the heat that lies beneath the Earth's surface.
- tidal energy, the exploitation of tidal energy in coastal areas with high tidal ranges.

It is important that a farmer, or an entrepreneur, choose the technology that is best suited to the energy needs of the farm and the company. Farmers may choose renewable energy systems for very different reasons, and the size and location of properties may affect the types of renewable energy systems that the farmer can choose.

The first thing a farmer and/or entrepreneur must consider is whether a renewable energy system will provide the required production. The second thing to consider is how existing agricultural operations can be better integrated with available renewable technology solutions. Therefore, many factors must be taken into account:

- the amount of energy required and the location of the company;
- how much the farmer and/or contractor is willing to spend;
- the size of the subsidies, the financial tools available.

All these factors will have a role to play in the decision-making process for the different sizes of companies along the agri-food chain.

Decision support tools must be implemented before the implementation of a technology used to rationally exploit energy resources or investment from the RE source chosen by the farmer and/or contractor. Here are some of them.

- Feasibility analysis: when planning an investment, the operator or project manager must first carry out a feasibility analysis. This tool is used to determine whether or not a project can be completed successfully.
- Technical analysis: technology adoption goes through different stages:
    - awareness of the company and/or farmer who is learning the technology, the practice;
    - evaluation by a company or a farmer of the technology in terms of costs and benefits;
    - adoption by a company or a farmer who decides to adopt it in full but modifies or adapts it according to the local situation and particular needs.
- Business models or business ecosystems: it is a continuous improvement tool that allows the company or the farmer to evolve in performance.

Ownership and sustainability depend on the participation of all stakeholders in electrification projects or changes in energy resources.

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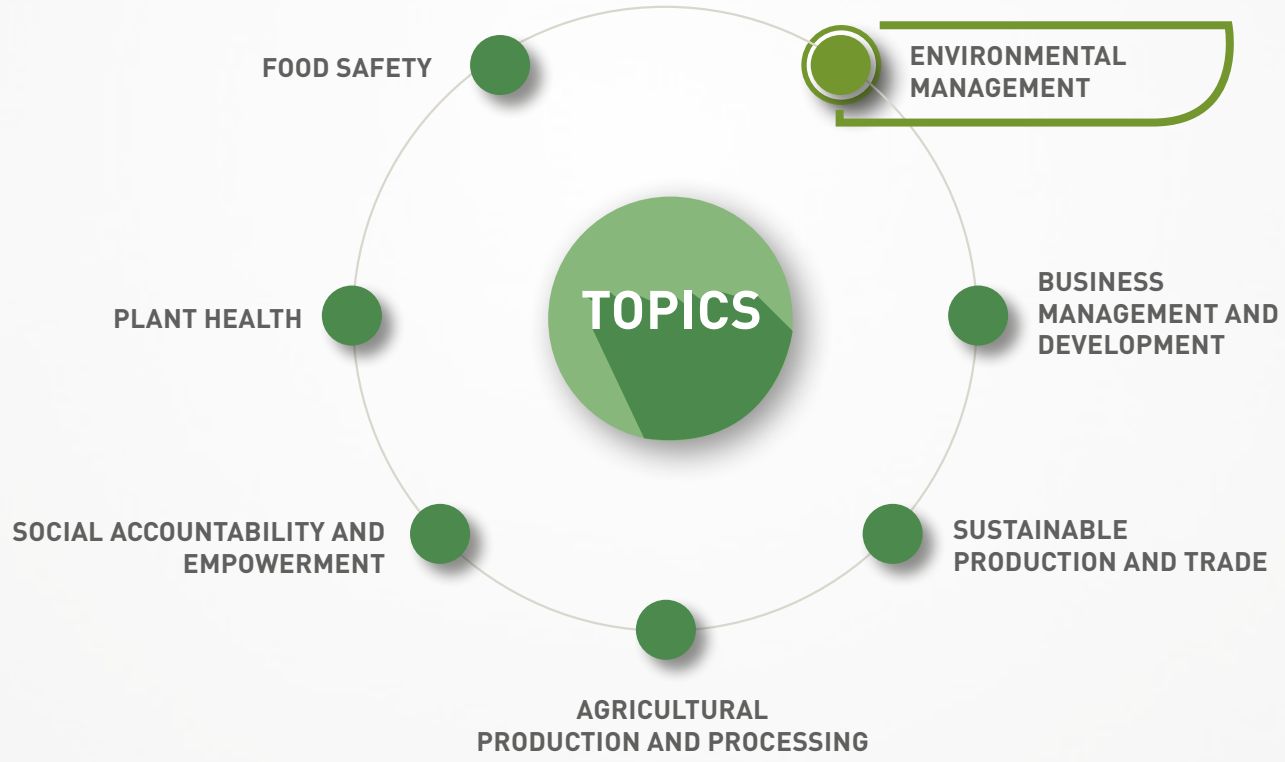

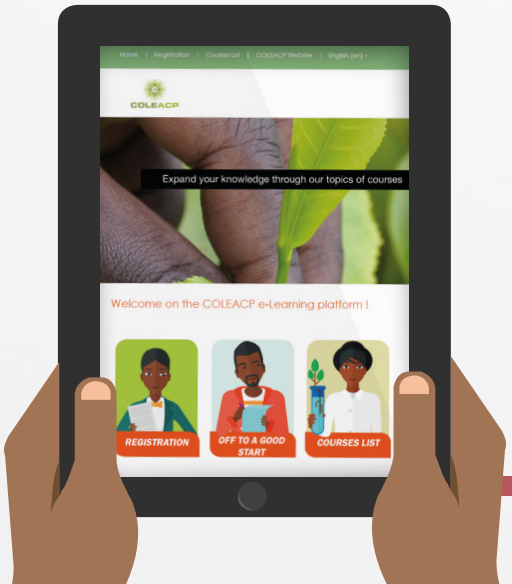

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