WORLD FARMERS' ORGANISATION

FARMERS IMPLEMENTING THE PARIS AGREEMENT ON CLIMATE CHANGE

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ABOUT THIS BOOKLET

Farmers, especially small-scale rural farmers, are directly affected by the severe weather events caused by climate change. However, they also represent part of the solution and by using climate smart agriculture practices as well as installing renewable energy technologies on their farms/land they can considerably help in reducing the possible risks related to climate change.

Many farmers already use renewable energy technologies and adaptation/mitigation techniques on their farms. Renewable energy and farming are a winning combination. This is because wind, solar, and biomass energy can be harvested continuously and are constantly replenished, providing farmers with a long-term source of income. In addition, renewable energy can be used on the farm to replace conventional fossil fuels.

This booklet contains a collection of case studies showing the contribution that farmers all around the world are already making in tackling climate change by generating and using renewable energy in agriculture along with adaptation and mitigation techniques. The booklet also shows how farmers are supporting significantly the implementation of the Paris Agreement.

The cases included in this booklet, have been selected by WFO's members from different regions all around the globe.

Dr. Marco Marzano de Marinis

SECRETARY GENERAL
World Farmers' Organisation, WFO

PROBLEMS/ CHALLENGES

OF CLIMATE CHANGE

Climate change represents one of the greatest challenges in the 21st century. The increase in global temperature is causing profound changes in the earth's natural systems.

Moreover, an increase in the frequency and intensity of extreme climatic events is seriously threatening the future sustainability of agricultural systems.

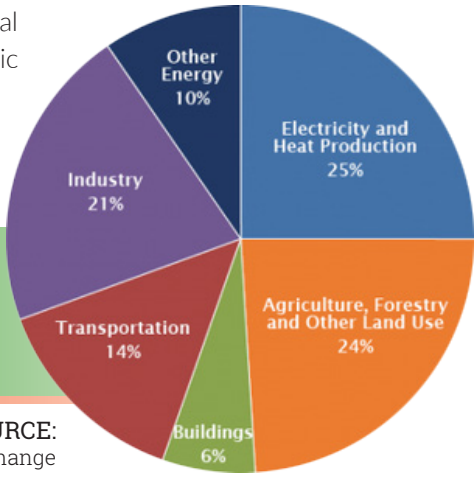
According to the United Nations, an increase of 3 degrees Celsius in global temperature could have drastic effects on water and food supply, biodiversity, pests, disease proliferation and outbreak, and planting/harvesting times, among others. Scientists believe that it is essential for global agriculture and food security to achieve the long-term goal of limiting global temperature increase to less than 2 degrees Celsius compared to pre-industrial levels, in order to avoid catastrophic consequences.

Risks of negative impacts on crop yields will greatly increase above this threshold; some studies predicting yield reductions for major crops of up to 25% by 2050 while food demand continues to rise with a growing world population.

Implications and concerns about potentially dangerous climate change and its associated environmental degradation have been addressed within national, regional and multilateral fora. On December 2015 at the Paris Climate Conference (COP21), 195 countries adopted the first-ever universal, legally binding global climate deal. This agreement has a global action plan to avoid dangerous climate change by limiting the global warming temperature well below 2 degrees Celsius.

> "Warmer temperatures have triggered severe weather events such as droughts, flooding and early frosts."

GLOBAL GREENHOUSE GAS EMISSIONS
by Economic Sector 2010



SOURCE:
Intergovernmental Panel on Climate Change

FARMERS AT THE CENTRE OF

CLIMATE CHANGE RELATED EVENTS

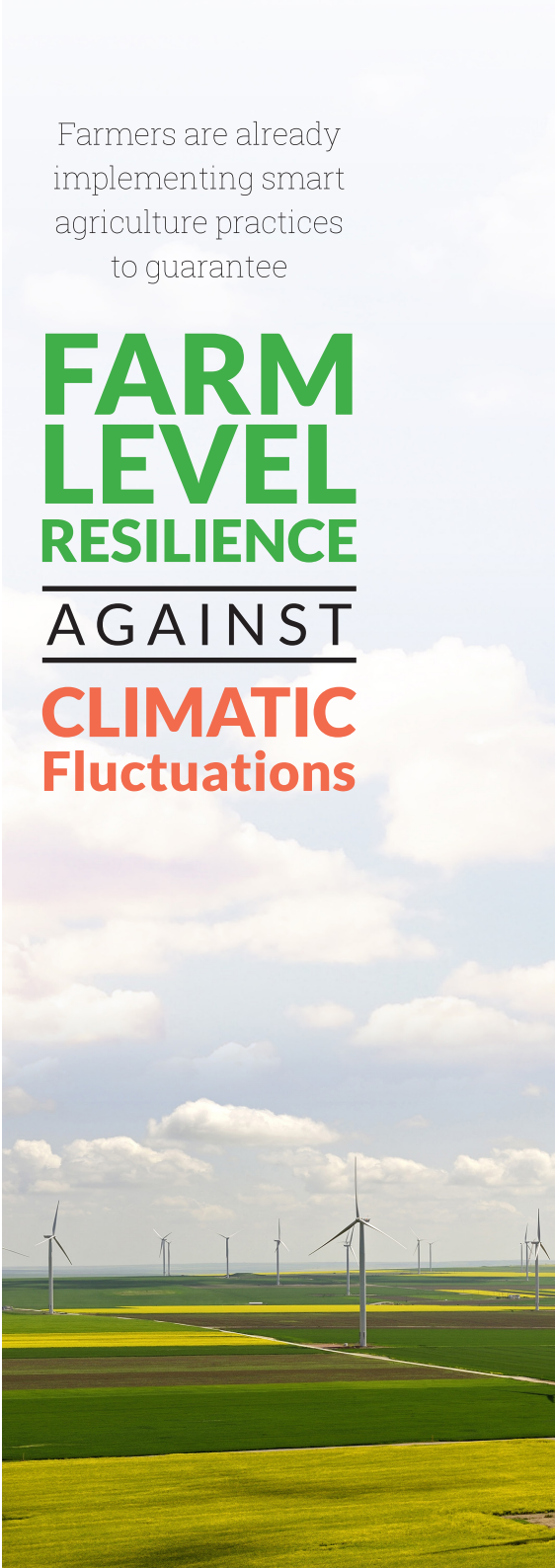
The global agriculture industry accounts for about 13.5% of greenhouse gas emissions. Mainly, the gases involved are methane (from ruminant livestock) and nitrous oxide (from soil management).

However, farmers, especially small-scale farmers in rural areas, are directly affected by climate change not only in guaranteeing food security but also in building resilience to the effects of climate change and in reducing mankind's emissions of greenhouse gases. The consequences of climate change can and have a drastic effect on the land where farmers work.

Farmers are also part of the solution to climate change. As the world population increases (with a projection of 10 billion by 2050), agricultural production must also increase. But with a more favourable policy environment and better incentives they could strengthen their role in reducing their vulnerability.

Farmers are already implementing smart agriculture practices to guarantee

FARM LEVEL RESILIENCE AGAINST CLIMATIC Fluctuations



Renewable technologies represent a viable solution in reducing global warming and a “clean” alternative to conventional fossil fuels for generating heating and electricity.

RENEWABLES

POSSIBLE SOLUTION

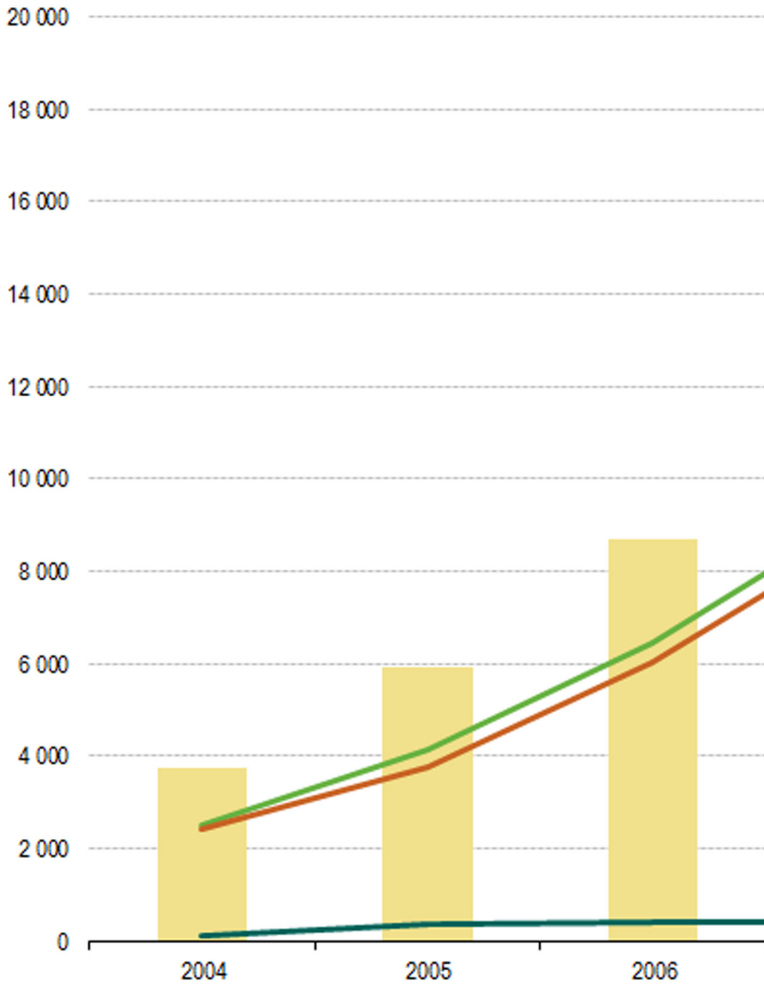
Energy consumption, in terms of electricity, heating and hot water, is also expected to increase rapidly. Therefore, it is essential to find viable alternative sources of clean energy that at the same time help to reduce global warming.

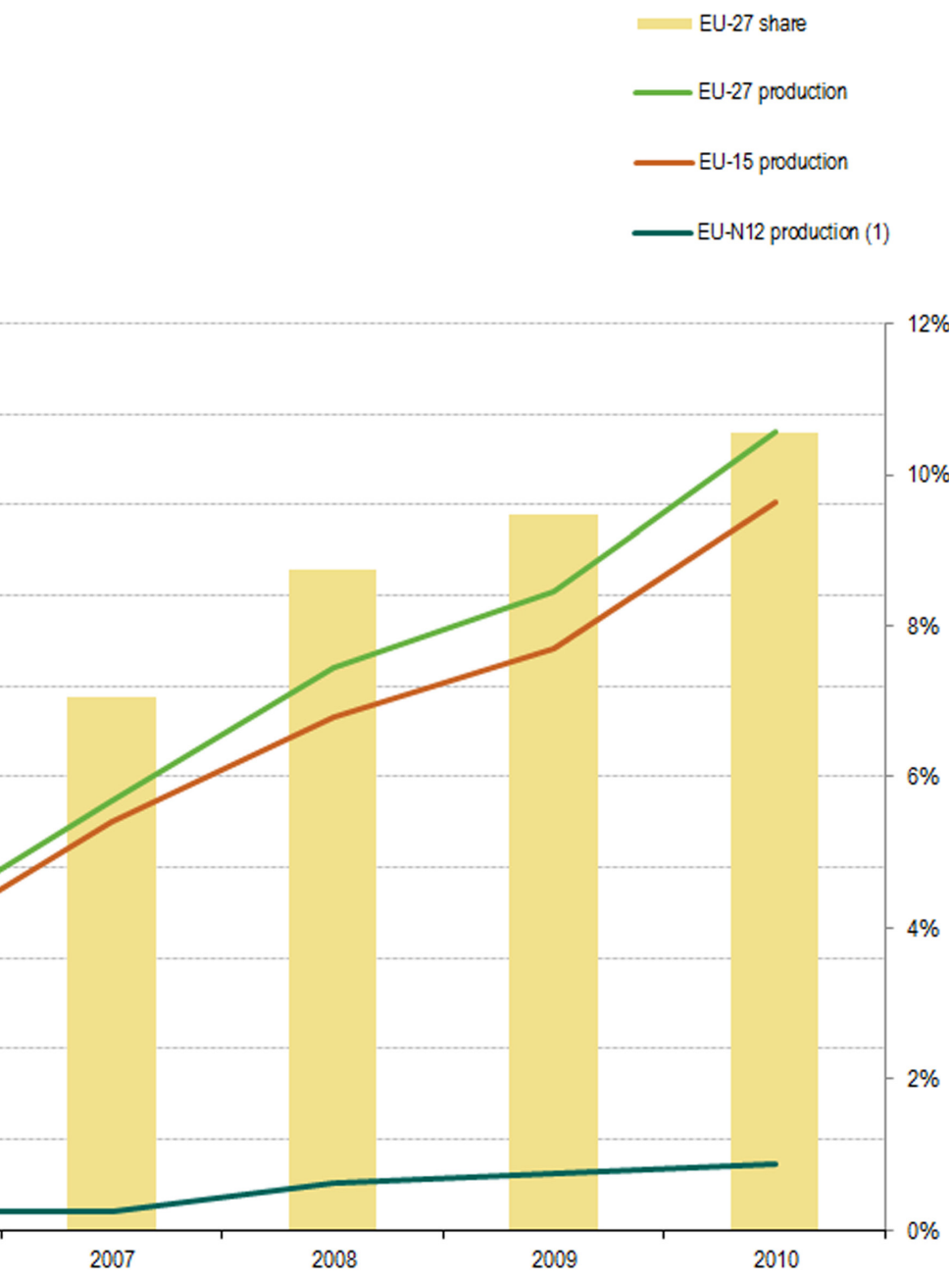
The advent of renewable energy has a great potential to revert the projected trends. Renewable energy can be described as power generated by natural sources that are constantly replenished. The utilization of renewable energy technologies does not contribute to resource depletion. Examples of renewable sources include solar, wind, biomass, hydropower, and geothermal. As mentioned earlier, renewable energy and agricultural activities are directly related and can be considered as a natural fit. This is because renewable sources of energy such as wind and solar energy are replenished constantly and unlike fossil fuels they will never run out. Therefore, it makes perfect sense for farmers to implement renewable technologies such as solar panels, wind turbines or biogas plants on their farmland in order to reduce global GHG emissions and at the same time obtain a long-term source of income.

RENEWABLE ENERGY PRODUCTION FROM AGRICULTURE IN THE EU

(2004-2010)

Source: European Commission





(1) Member States which joined the EU in 2004 and 2007 (BG, CZ, EE, CY, LV, LT, HU, MT, PL, RO, SI and SK)

SOLAR ENERGY

PV & SOLAR THERMAL TECHNOLOGIES

The largest renewable energy potential on earth is provided by solar irradiation.

Solar collectors are typically divided into two categories:

SOLAR THERMAL

Solar thermal collectors are devices that convert incident solar radiation into hot water that can be used for domestic purposes. The main part of a solar thermal system is the collector. The collector is able to absorb the incoming solar radiation and transfer the resulting heat, to the working fluid (normally air or water). The fluid that flows through the collector, carries the heat out of the system. This heat can then be used to provide hot water for buildings.

SOLAR PHOTOVOLTAICS (PV)

From the various solar technologies available on the market, solar PV represents one of the simplest and reliable technologies that directly convert solar energy into electricity, which is the most suitable form of energy for utilization. Solar PV is considered to be a promising technological solution that can sustain global transformation to a low-carbon economy and at the same time significantly reduce dependency on fossil fuels.

> The use of solar energy systems denotes a clean and carbon-free approach to generating electricity and heating for buildings.

Fig. 1 - Solar Photovoltaic Panels

BIOMASS
ANAEROBIC DIGESTERS & BIOMASS BOILERS

Biomass is an example of a renewable source that can be used to generate clean energy. It is essentially any organic material derived from living or recently living organisms.

Biomass is often referred to be a carbon neutral source and this is because the CO2 emitted by the combustion of biomass is fundamentally carbon absorbed by plants during photosynthesis in the previous few months or years. Therefore, a sustainable balance is maintained between the carbon emitted and absorbed. However, biomass can only be considered sustainable if the amount consumed is less than the amount of additional biomass that grows over the course of a year in a given area. Biomass can be divided into the following five basic categories: Virgin Wood, Energy Crops, Agricultural Residues, Food Waste and Industrial Waste (Source: Forestry Commission for England and Scotland).

Bioenergy is the conversion of biomass to generate heating, electricity and fuel. Biomass boilers fuelled by wood chips or pellets are generally used for heating. Electricity by biomass is normally produced in power plants where biogas produced by agricultural and/or municipal solid waste, is used to turn a turbine.

Another method of generating heat or electricity by biomass is using anaerobic digesters to produce methane. Anaerobic digestion is a natural process where plant and animal based material is broken down by micro-organisms in the absence of air. The process begins when biomass is put inside a sealed tank also known as a digester. Naturally occurring micro-organisms digest the biomass, which releases a methane-rich gas (biogas) that can be used to generate renewable heat and power; this helps cut fossil fuel use and reduce greenhouse gas emissions. The remaining material (digestate) is rich in nutrients, so it can be used as a fertiliser.

Biomass resources are also used in the transport industry. In fact, plant or animal waste can be used to produce biodiesel by oil extraction.

Fig. 2 - Wood Chips Used as Feedstock for Biomass Boilers

WIND ENERGY

POWER GENERATION USING TURBINES

Wind is a free source and is constantly replenished. Wind turbines use kinetic energy and convert it into mechanical power via rotor blades. The blades are turned by the wind and as this happens, the shaft connected to the generator also turns thus generating electricity. This electricity generated can then be connected to the grid.

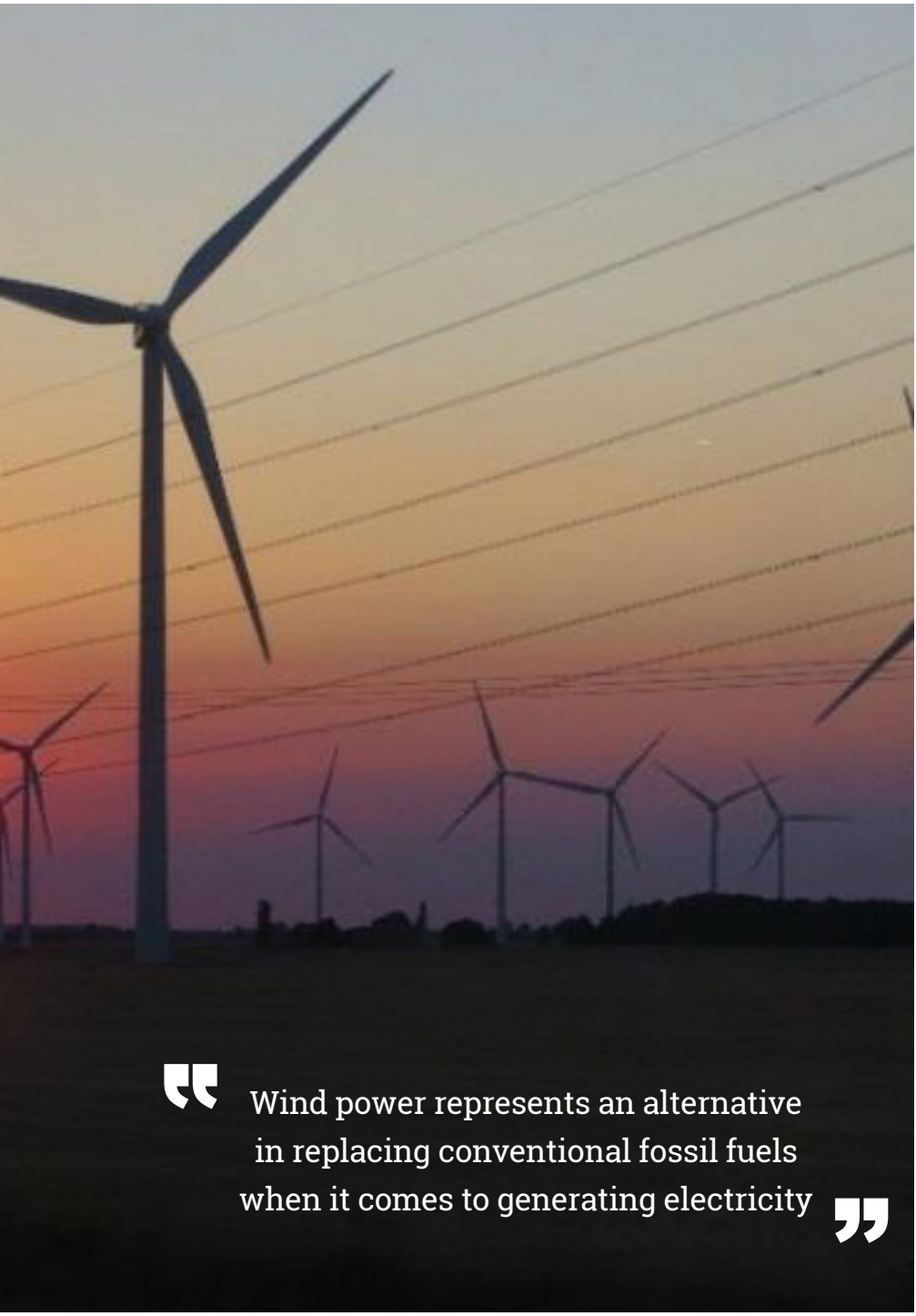
Wind turbines come essentially in two types:

Horizontal Axis Wind Turbines
(HAWT)

Vertical Axis Wind Turbines
(VAWT)

The most common type of wind turbines operate on a horizontal axis. These turbines are able to produce more electricity from a given amount of wind and are generally used for large wind applications. Vertical axis wind turbines on the other hand, are used for smaller applications but can perform well in turbulent wind conditions.

Fig. 3
Wind Farm using HAWT



> Wind power represents an alternative in replacing conventional fossil fuels when it comes to generating electricity

CASE STUDY 1

BIOGAS TRANSFORMING LIVES OF RURAL FARMERS, KENYA (KENAFF)

Problems caused by Climate Change

An estimated 85% of the population in Kenya relies on traditional fuels such as wood, charcoal, dung and agricultural residues for cooking and heating. Forest resources in the country are diminishing fast, thus reducing access to the rural population's only energy source. Farmers are also facing other challenges as a result of climate change including changing rainfall patterns, rising temperatures, declining agricultural production, soil erosion and increase in diseases.

Technology Implemented and Necessary Investments

The Kenya National Farmers Federation (KENAFF) with support from two Dutch NGOs, Hivos and SNV has been promoting the uptake and use of domestic biogas by rural households in Kenya since 2009. This programme was designed to encourage biogas technology among Kenyan small scale farmers with animal manure being used as feedstock for small size biogas digesters. These digesters provide farmers with sufficient energy for cooking and lighting, totally substituting for the use of firewood and kerosene. Bioslurry, the effluent from the digester is then used in various ways on the farms to enhance agricultural production, direct use as liquid fertilizer and allowing for diversification with farmers venturing into fish farming. The farmers are required to invest an initial equivalent of $ 600 to install a biogas digester.

Impact/Outcome

THE USE OF BIO SLURRY HAS HAD A VERY POSITIVE IMPACT WITH MOST FARMERS REPORTING UP TO 60% INCREASE IN AGRICULTURAL PRODUCTIVITY

and enhanced produce quality; and there is clear evidence of significant improvement in soil structure, condition and fertility. The adoption of this technology has also significantly improved the welfare of poor rural women through the reduction of time spent in fuel wood collection and by reducing their exposure to toxic fumes from cooking over open fires, thus improving their health.

Fig. 4 - Bio Slurry application as liquid top dress fertilizer

CASE STUDY 2

LAFORGE BIOENVIRONMENTAL FACILITY, CANADA (CFA)

Problems caused by Climate Change

Laforge Holsteins Ltd. is a 4th generation farm in New Brunswick, Canada, with 200 dairy cows. With heating, electricity and fertilizer costs increasing, Laforge Holsteins Ltd. decided to advance on the renewable energy side to reduce greenhouse gas emission and become more self-sufficient. In 2009, the farm formed Laforge Bioenvironmental Inc. and installed a biodigester.

Technology Implemented and Necessary Investments

Laforge Bioenvironmental is an on-farm biogas facility with 2 reactors, called digesters, and 2 co-generation units that produce electricity. The system takes the dairy manure, and residual organic waste from local food processing plants and converts it into biogas, electricity and organic fertilizer.

Being the first biodigester in New Brunswick, the farm was able to obtain funding support from some agricultural and climate change agencies within the federal and provincial governments. Despite a large upfront investment for the farm, the biodigester will pay itself off within 10 years, due to savings in heat and fertilizer, as well as sales of electricity.

Impact/Outcome

Laforge Bioenvironmental process around 43,000 tons of organic waste, and has the capacity to process 190,000 tons.

The by-product of this facility is a rich organic fertilizer that can be spread on farmland. Since the biogas plant began operating, the farm has saved heating costs and has eliminated chemical fertilizer purchases. They also have cut about 90% of their greenhouse gas emissions from manure, while helping local industries reduce their environmental waste and helping them meet their own emission and waste reduction quotas.

The plant generates 1500kW of electricity per hour, or 13 million kW per year, enough to supply 1000 homes.

Fig. 5 - Biogas Engine at Laforge Bioenvironmental

CASE STUDY 3

RAUHAMAKI FARM SUPPLYING ENERGY WOOD TO UPM BIOREFINERY, FINLAND (MTK)

Problems caused by Climate Change

Agriculture and forestry are facing increasing challenges also in the global North. Finnish family forest owners and farmers are facing these practical challenges on the frontline. The risk of floods, pests and diseases are increasing despite the continuous hardwork to prevent them. One special character of the changing climate are milder winters and lack of decent frost and snow coverage, which causes problems to forestry operations.

Technology Implemented and Necessary Investments

The Rauhamaki farm is a farm situated in southern Finland with 30 hectares of forest. Almost every year they sell wood that goes to nearby sawmills but the residues, like branches and small trees, are sold as energy wood.

> "The farm supplies wood to the energy co-operative in the village and uses it to heat the school, elderly home and some other communal buildings."

The farm's Forest Management Association buys a lot of energy wood from its members, about 200,000 cubic meters per year. It delivers the wood to various buyers that use it to produce heat and energy but also for example to make biofuels like biodiesel.

One of the buyers to which the wood is supplied to is the UPM Biorefinery, the world's largest biorefinery that makes biodiesel from wood residues. It produces 100,000 tonnes or 120 million litres of renewable biodiesel per year. The total investment needed to start the plant was of EUR 179 million. The main product of the biorefinery is renewable biodiesel.

Impact/Outcome

Economically, the selling of energy wood provides a good additional income for the farm. It is also important to feel like part of the chain that produces sustainable energy, helps to prevent climate change and keeps the local economy alive. The results can be seen from the energy statistics. Wood energy in different forms has risen as a dominant source of energy in Finland.

Fig. 6 - UPM Biorefinery

CASE STUDY 4

BIOGAS PRODUCTION IN GERMANY (DBV)

Problems caused by Climate Change

As is the case with other countries, climate change has had quite some impacts in Germany. Negative impacts include the spread of Drosophila suzukii, an invasive fly species that harms especially wine-production, or the increased risk of extreme weather events like heat waves, droughts or heavy rainfall.

Technology Implemented and Necessary Investments

In the early 2000's, when the EEG – the renewable energy law – introduced special feed-in-tariffs for renewable electricity, the number of installed biogas plants in Germany increased.

These biogas plants run on energy crops such as maize or sugar beet, but also on manure. Cattle manure is especially suited for biogas plants and produces biogas with a high methane content.

A new and innovative example of a biogas plant is currently planned in the Münster region, which boasts a high livestock density. This plant is expected to use 200.000 t of liquid cattle and pig manure per year. As a first step, solid matter of the liquid manure, which is to be used in external biogas plants, is separated. The remaining liquid slurry is digested. Following several other conversion steps, this plant will annually produce (in addition to electricity and heat) 1,200 t of valuable nitrogen and phosphorus fertilizer each.

Impact/Outcome

Biogas plants have many benefits both for farmers and for the environment. For example, they generate additional income through the sale of electricity and heat and thus improve financial sustainability and stability of farms. Moreover, they have positive impacts on the environment. Methane emissions from manure are minimized and renewable energy is produced, tackling climate change and paving the way for the bioeconomy.

Fig. 7 - Biogas Plant in Germany

In 2015 more than 8.000 biogas plants with a cumulative capacity of about 4.000 MW were installed.

CASE STUDY 5

SUSTAINABLE DAIRY PRODUCTION AT ARLA FOODS, DENMARK (DAFC)

Problems caused by Climate Change

In 2011, Arla Foods launched its environmental sustainability strategy. As the largest environmental impact occurs at primary production, it was only natural to also include farm level, in addition to the stages where Arla has a more direct influence, such as processing, transport and packaging. Another aspect frequently discussed in relation to food security and resource efficiency is food waste, especially at consumer, why it was highly relevant to include the consumer level as well. Thus, the environmental strategy had goals covering the whole value chain from cow to consumer.

Technology Implemented and Necessary Investments

To reduce energy use, detailed analyses was carried out on all Arla's plants in Denmark. Each plant made a complete overview of the energy use and a detailed optimisation plan. This was done by installing a biogas plant in order to produce renewable biogas (methane) using anaerobic digesters that use cow manure as the principle feedstock source.

> Arla's mozzarella dairy in Rødkærsbro's, Denmark, managed to halve its use of natural gas compared to previous years.

Fig. 8 - Carbon footprint assessment at farm level

Impact/Outcome

Today, 18% of Arla's total energy use comes from renewable sources and the GHG emissions have been reduced with 14% at site level in 2014 compared to 2005.

The latter is despite an increase in production; hence per unit produced the reduction is even larger.

CASE STUDY 6

PRODUCTION OF CLEAN ENERGY USING HEAT OF FRESH COW MILK, NETHERLANDS (LTO)

Problems caused by Climate Change

In times of broad public discussions about renewable energy sources, small key innovations are often overlooked. In the Netherlands for example, there are many agricultural entrepreneurs making efforts and investments to be as sustainable as possible. Everything on his farm shows that dairy farmer Jan Pieter van Tilburg from Hellum (a small town in the north of the Netherlands) is dedicated towards utilising energy the most sustainable way. When he opened his new dairy farm back in 2014, it was entitled "The most energy efficient dairy farm in Europe". Within his farm, the "ECO200-system" is the key factor in his ambition to be energy neutral in the future.

Technology Implemented and Necessary Investments

The ECO200-system is a relatively new technology that was developed by a study group, which van Tilburg was part of, on renewable energy. Furthermore, the generated energy is used in the boiler of his own house. In addition to the re-use of energy, the ECO200-system has another advantage. It charges the net power much more evenly with smaller peaks in electricity usage, making it also a sustainable use for the involved machinery.

Impact/Outcome

Where regular dairy farms use about 45 kWh per 1.000kg of milk, van Tilburg only uses 25 kWh. The energy bill has declined by EUR 3,500 on a yearly basis, resulting in a payback time of about 8 years for the ECO200-system.
ECO200 is not the only sustainable technology van Tilburg wants to use on his dairy farm. He also has solar panels installed on his roof and is making progress on purchasing a small windmill. Eventually, he wants to shift to only renewable electricity and become fully self-sustaining.

> The system generates energy from the heat of fresh milk and uses the energy for the cooling system of the milk.

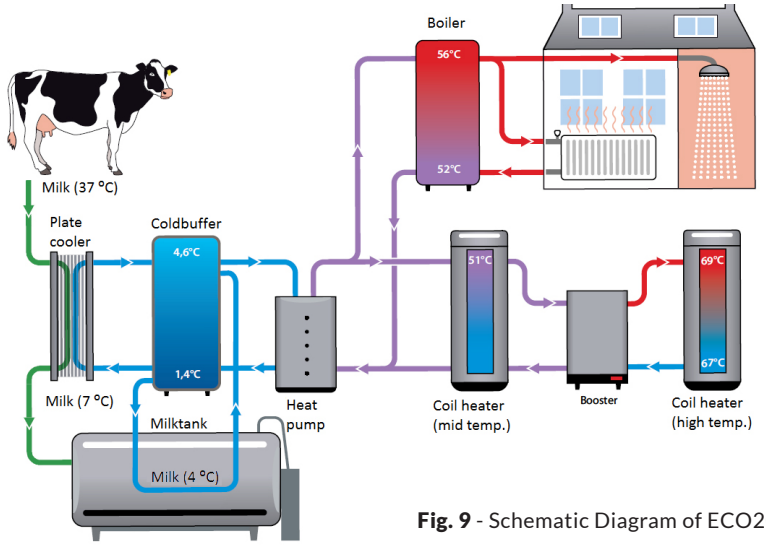


Fig. 9 - Schematic Diagram of ECO200

CASE STUDY 7

BIODIESEL PRODUCTION USING SUNFLOWERS, AUSTRIA (ANCAF)

Problems caused by Climate Change

Several years ago, Alfred Papst, a farmer, contractor and innovative pioneer in sunflower farming, began pressing the oil out of sunflower seeds and mixing it with diesel for use as a substitute fuel for his tractors. He came up with this idea as an alternative method of reducing GHG emissions produced by his tractors. This novel approach convinced other farmers in the Fürstenfeld region to look further into the possibility of using vegetable oil as a fuel. Quickly, people began advocating local fuel production and eventually, a joint venture was formed.

Technology Implemented and Necessary Investments

The venture was formed by several farmers and is named "FürstenÖLfeld". At present, it has 24 members. The joint venture's oil mill, which has been in operation since September 2005, is located on the grounds of a biogas plant, where part of the press cake can be used for the production of heat and electricity. The vegetable oil production system is operated in a continuous process and has a capacity of up to approximately 60 kg of oil-bearing seeds per hour – enough to produce 20 kg or 21.5 litres of oil per hour (conversion: 1 litre oil = 0.93 kg oil).

That amounts to a vegetable oil volume equal to 34.5 tonnes or 37,200 litres. The raw material "sunflower" is grown by the members of the vegetable oil joint venture. This ensures long-term availability of the raw material supply.

Impact/Outcome

The vegetable oil mill produces about 30,000 litres of vegetable oil per year. On average, that volume is sufficient to farm approximately 280 hectares of land per year using a locally produced, eco-friendly fuel. If this environmentally sustainable raw material could be utilised for mobility purposes, the carbon dioxide footprint would be reduced by some 81 tonnes per year.

> During the past five years, an average of about 110 tons of sunflower seeds has been pressed annually.

Fig. 10 - Tractor fuelled by sunflower biodiesel

CASE STUDY 8

SOLAR DRYING OF MANGOES ON CHANKWAKWA FARM, ZAMBIA

Problems caused by Climate Change

The Chankwakwa farm was established by Dorothy Eriksson and her husband Rolf in Kabwe, Zambia, in 1973. The couple wanted to enter the dried fruits/vegetables business and also looked to export mangoes overseas. However, due to various international standards and regulations the farm had to be more sustainable in the production and drying of fruits and vegetables. Therefore, attaining the Hazard Analysis Critical Control Point (HACCP) certification was necessary.

Technology Implemented and Necessary Investments

With training and support from several organizations, including the International Trade Centre (ITC), the Erikssons learned about organic certification.
But in order to function as a more sustainable and environmentally friendly business,

SIX SOLAR-POWERED DRYERS WERE INSTALLED IN CHANKWAKWA ALONG WITH A LARGE HYDROPOWERED ELECTRIC DRYER TO PROCESS THE FRUITS AND VEGETABLES.

Once they are processed, they are used in jams or sauces, or packaged as dried fruit to be sold in markets around the country.

Impact/Outcome

Today Chankwakwa employs 232 farmers to harvest fruits and vegetables, with one group working near the processing plant in Kabwe and another in the Luapula Province. ITC-assisted farmers in Luapula receive organic certification and training on the management of mango trees, which has resulted in higher quantities of the fruit and an expanded mango-processing season. Since its transition in 2000 from a farm-only business to a food-processing company, revenue has grown about 200%.
The story of Chankwakwa is an impressive success. Once again, farmers through innovation and the use of sustainable renewable technology have made a real difference to their community and on a global scale.

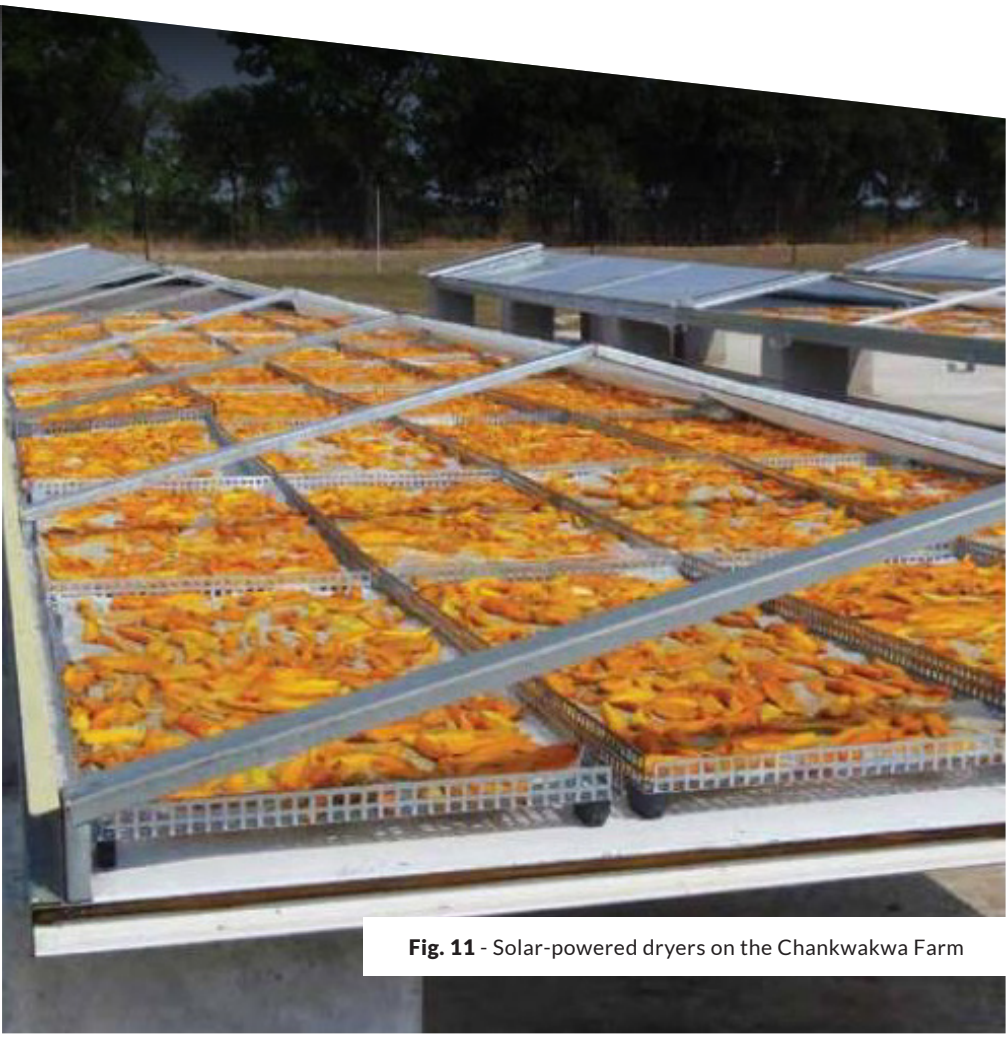


Fig. 11 - Solar-powered dryers on the Chankwakwa Farm

CASE STUDY 9

SMALL SCALE FARMERS USING ENERGY SAVER STOVES, MALAWI (NASFAM)

Problems caused by Climate Change

Forests and farmers' woodlots are declining at an alarming rate due to the cutting of trees to open new lands for farms and settlement, for sale as fuel wood and for construction. For these reasons, NASFAM promotes the planting of trees every year among its farmer members in order to help improve the farmers' access to fuel wood, restore forests, reduce soil erosion and greenhouse gases. To date, over 17 million trees have been planted and 10 sites are under farmer-managed natural tree regeneration. However, due to population growth, there is a marked increase in demand for fuel wood as a source of energy. Therefore, NASFAM introduced Energy Saver Stoves – "the Chitetezo Mbaula" - to mitigate the problem.

Technology Implemented and Necessary Investments

The energy saver stove implementation by NASFAM started with a farmers group in Balaka Innovation and Productivity Centre in August 2013 where 55 NASFAM members (34 women and 21 men) participated. In 2014, NASFAM's effort successfully expanded to 6 new groups in Mulanje, Phalombe, Balaka-Chilipa, Nkhotakota, Mchinji, Kasungu and Mzimba reaching 434 farmers (294 female and 140 male) as stove producers.

They are locally known as Chitetezo mbaula which literally means "stoves which protect". They significantly reduce fuel wood usage by two thirds (67%) compared with the commonly used three-stone open fire.

THE STOVES RELEASE LITTLE SMOKE AND FUME TO THE AIR LEAVING HOUSEHOLD MEMBERS WITH ADEQUATE ACCESS TO CLEAN AIR.

They are portable and well known for reducing burns among users.

Impact/Outcome

The "Chitetezo Mbaulas" are quickly becoming a viable income-generating activity especially among rural women. They are generally smart to use because cooking pots attract little soot which also requires less energy, time and water to remove. The user also remains clean due to less soot, smoke and fume. Generally, people enjoy consuming food from chitetezo mbaula because it is food prepared in a clean environment and definitely helps in reducing emissions when compared to the normal stove.

Fig. 12 - Demonstration of effectiveness of Chitetezo Mbaula (left) versus conventional cooking method (right)

CASE STUDY 10

MEDIUM WIND TURBINE FOR FAMILY DAIRY FARM IN ENGLAND (NFU ENGLAND AND WALES)

Problems caused by Climate Change

Concern over the growing threat of extreme weather events, and worries about the volatility of milk producer prices, have led many dairy farmers to consider diversifying their income in order to remain in business. The Gilman family, tenant farmers near Tamworth in Staffordshire, installed a medium-sized wind turbine 4 years ago to meet some of their business energy needs and to provide additional income from exported electricity. A herd of 200 dairy cattle and a small arable operation is managed on 160 hectares by three generations of the family, selling their milk through Arla Foods to a major supermarket chain.

Technology Implemented and Necessary Investments

The 50-kilowatt Endurance wind turbine was installed in November 2012, about 300 metres from the farmhouse where it can barely be heard. Despite some local objections, obtaining planning permission was not difficult, although an upgraded electricity pole transformer was an unexpected cost. Although eligible for support under the UK Government Feed-In Tariff scheme, bank finance also took some time to agree, since as tenants the Gilmans do not own their farmland. In addition, they have a 90-kilowatt biomass log boiler to heat the large farmhouse, which is divided into two independent family dwellings. This heating system is backed by the Government Renewable Heat Incentive programme, using farm-grown wood and fuel purchased from off site.

Impact/Outcome

Over 600 turbines of this type have been installed across the UK – on an annual basis, each one produces power equivalent to the needs of 35-50 households.

OVER THE PAST 4 YEARS, ONE-THIRD OF THE OUTPUT FROM THE GILMANS' TURBINE HAS BEEN USED TO POWER MILKING MACHINERY AND OTHER ON-SITE FARM DEMAND,

with the remainder being exported to the local electricity network. Every year, the Gilmans participate in Open Farm Sunday, where the turbine has attracted considerable public interest as a local landmark.

Fig. 13 - Three generations of the Gilman dairy farming family, in front of their farm wind turbine (David and Lesley, left, Andrew and Lyneth, right, Evan, Jonty and Eliza, centre)

Mease Valley Photography, Tamworth

CASE STUDY 11

SHEEP-GRAZED SOLAR FARM IN ENGLAND (NFU ENGLAND AND WALES)

Problems caused by Climate Change

Farming income in West Dorset has been poor for the past decade or more, so hosting a 27-acre (11-hectare) solar farm offered an opportunity for agricultural diversification into clean, green renewable energy. Farmers Clive and Jo Sage were determined to continue raising Poll Dorset lamb at Wyld Meadow Farm near Bridport, while earning an income from solar energy production on their land. The family have farmed this land for many generations, and they specialise in locally produced beef and sheep, with 90% of their lamb being sold within a 40 mile radius of the farm. Clive and Jo looked for a solar farm developer that was willing to offer them grazing rights for the operational lifetime of the project.

Technology Implemented and Necessary Investments

Installed in 2012, the Wyld Meadow solar farm was designed to have very low local visual impact, including an agreement with the project developer and investors to ensure livestock grazing throughout the project's lifetime. It comprises nearly 21,000 solar modules, each rated at 240 watts, mounted on locally-made steel framework designed specifically to enable sheep to have full access to pasture. All electrical cabling is armoured against sheep damage or tucked away neatly out of reach of the livestock. To enhance biodiversity at the site, small bird and owl nesting boxes were installed by the developers in the trees surrounding the field.

Impact/Outcome

As a leading example of good practice, the Sages and their solar farm have been featured extensively in the local media and the agricultural trade press, as well as in a national guide on integrating solar farms into agriculture. Visitors to the project have included numerous local politicians and a Government minister.

> "The solar farm generates over 4.5 million kilowatt-hour electricity units per year, enough to meet the annual needs of over 1100 homes."

Fig. 14 - Wyld Meadow Solar Farm (Project Developer Renewables encouraged grazing within the solar farm)

CASE STUDY 12

BIOGAS PLANT ON DAIRY FARM IN CASERTA (COLDIRETTI)

Problems caused by Climate Change

Letizia SRL is a farm established by Mr. Critofaro Letizia in 1970 located in the municipality of Pietramelara, Caserta. The main purpose of the farm is the production of milk, but the intent, is to create a food chain that facilitates a better product every time and leads to the highest yield at all production phases, optimizing any resources. To this end,

A BIOGAS PLANT OF 100KW CAPACITY WAS INSTALLED IN ORDER TO CONTINUE THE PROCESS OF IMPROVING THE FARM,

diversify earnings and at the same time, to reduce emissions.

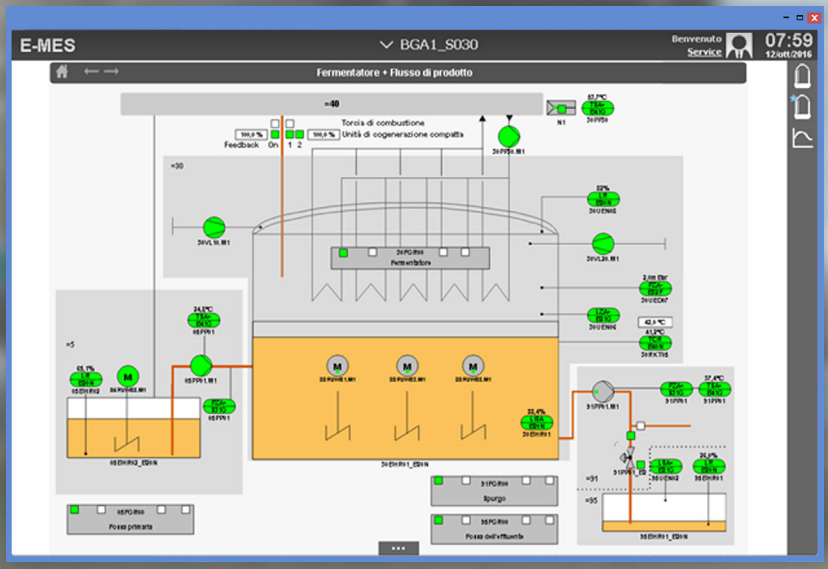
Technology Implemented and Necessary Investments

The daily collection of manure from livestock occurs by automated mechanical means. It is then transported through tubes into a primary pit where it is mixed constantly. Over the next 24 hours, the manure is pumped into the anaerobic digester where methane along with other gases are released. Using desulphurising bacteria and with the intake of air, the methane is purified. Subsequently, it is captured by a cogeneration unit and combusted, thereby generating electricity. The electricity is used for on-farm activities such as irrigation and the cogeneration unit also produces hot water which is conveyed to corporate users. Any excess current is connected to the grid and through the access of the all-inclusive tariff system, it is paid to the farm. The total investment of the project was of Euros 800,000.

Impact/Outcome

The payback period of the biogas plant is expected to be around 7/9 years considering the savings in utility bills and collection of the GSE payments for energy fed into the grid. About 10% of the turnover of the farm comes from the generation of electricity. The benefits of installing this system include that animal manure can be used for generating income for the farmers, zero investment in raw material, elimination of odors, elimination of nitrogen from the digestate, diversification with less business risk in terms of income and a first step in planning a further project for the better management of animal waste.

Fig. 15 - Schematic Diagram of Anaerobic Digester



CASE STUDY 13

FARMERS IN JAPAN USING BIOGAS TECHNOLOGY (JA – ZENCHU)

Problems caused by Climate Change

Global warming causes lower yields and quality of agricultural products including rice, fruit, and vegetables. It also brings harmful insects to the northern area of Japan. High temperature in the summer season affects livestock production such as dairy farming, decreases quantity and constituents of milk, as well as reproductive performance, coupled with increased animal disease. Lower levels of agricultural production and quality have a direct impact on farmers' income. Moreover, Japan has been frequently hit by heavy rain and destructive typhoons in the recent years, causing great damage to agricultural products, livestock, and farmland.

Technology Implemented and Necessary Investments

Some of the dairy farms have established biogas plants utilizing animal manures, which generate electricity by methane gas. By utilizing electric and heat energy derived from the biogas, they can supply stable electricity without depending on fossil fuels and contribute in reducing emissions. It also reduces the labor for manure disposal and helps dairy farms in being more efficient. Furthermore, the liquid by-product obtained through the methane fermentation can be used as a fertilizer with stable quality. However, it costs about 200 million yen to build a large-scale biogas fermentation facility, followed by additional running and maintenance costs. Because of these costs, most of the facilities have been built with financial support from the government or agricultural cooperatives.

Impact/Outcome

While greenhouses for horticulture in Japan are generally heated with a boiler using fossil fuel, in the face of rising oil prices, horticulture facilities are increasingly adopting energy saving technology such as "heat pumps" and wood biomass boilers using timber from forest thinning. A heat pump does not generate heat by burning fuel but generates heat energy by compressing cold outside air using electricity.

THESE TECHNOLOGIES CAN LOWER THE EXPENSIVE FUEL COST OF GREENHOUSE HORTICULTURE, AND REDUCE THE USAGE OF FOSSIL FUEL.

Fig. 16 - Biogas Plant in Japan

CASE STUDY 14

RENEWABLE ENERGY INITIATIVES BY FRENCH FARMERS (FNSEA)

Problems caused by Climate Change

Agriculture and forests are directly and severely impacted by climate change, for example through droughts, flooding and changes to the crop calendar. For those in the field, climate change is not merely a faraway theoretical concept; it is a part of their everyday lives. Agriculture, is continuously innovating and seeking means to adapt that will enable it to sustainably maintain and develop its activities, in order to feed the global population, in the decades to come. In the fight against the greenhouse effect, farmers in France have not been standing by idly.

Technology Implemented and Necessary Investments

Farmers in France have become involved in the field of renewable energy and have adapted by changing their farming practices. Agricultural and forest biomass account for two thirds of the renewable energy in France and over 40% of the effort to reach the target for 2020. Agricultural methanation enables the sale of electricity, heat, biogas injected into the natural gas network and biomethane fuel. As part of the call for bids sent out by the public authorities, French biofuel industries have invested massively (€2 billion) in new high-performance production plants. In addition, photovoltaics on the roofs of farm buildings play an important role in the development of renewable energy.

Impact/Outcome

IN FRANCE, EMISSIONS IN THE AGRICULTURE SECTOR HAVE ALREADY DECREASED BY 12% OVER THE PAST 22 YEARS DESPITE

the fact that production has increased significantly during this period. The energy consumption of the farming sector increased by 40% between 1970 and 2011. In relation to the GDP for agriculture, energy consumption at farms was 132 tonnes of oil equivalent (toe) per million € in added value in 2011, compared to 213 toe per million € in 1970, which represents an improvement in energy efficiency of around 40% (Source: CGDD-Observation and Statistics Department, May 2014).

Fig. 17 - Wind Power Generation on a French Dairy Farm

CASE STUDY 15

SUSTAINABLE AGRICULTURE IN ARGENTINA (Sociedad Rural Argentina)

Problems caused by Climate Change

DIRECT SEEDING CHANGED/REVOLUTIONIZED AGRICULTURE IN ARGENTINA.

Nowadays more than 90% of the cultivated area is under this technique which has the objective of achieving the sustainability of agricultural systems and to produce more and better.

While the cultivated area and the global food demand increase, the land management with rotations that include various crops in addition to direct seeding make sustainable agriculture possible.

Technology Implemented and Necessary Investments

Nevertheless, direct seeding alone is not enough to achieve that objective since it is fundamental to look at the system as a whole and to adopt the re-

Fig. 18 - Direct Seeding on a Farm in Argentina

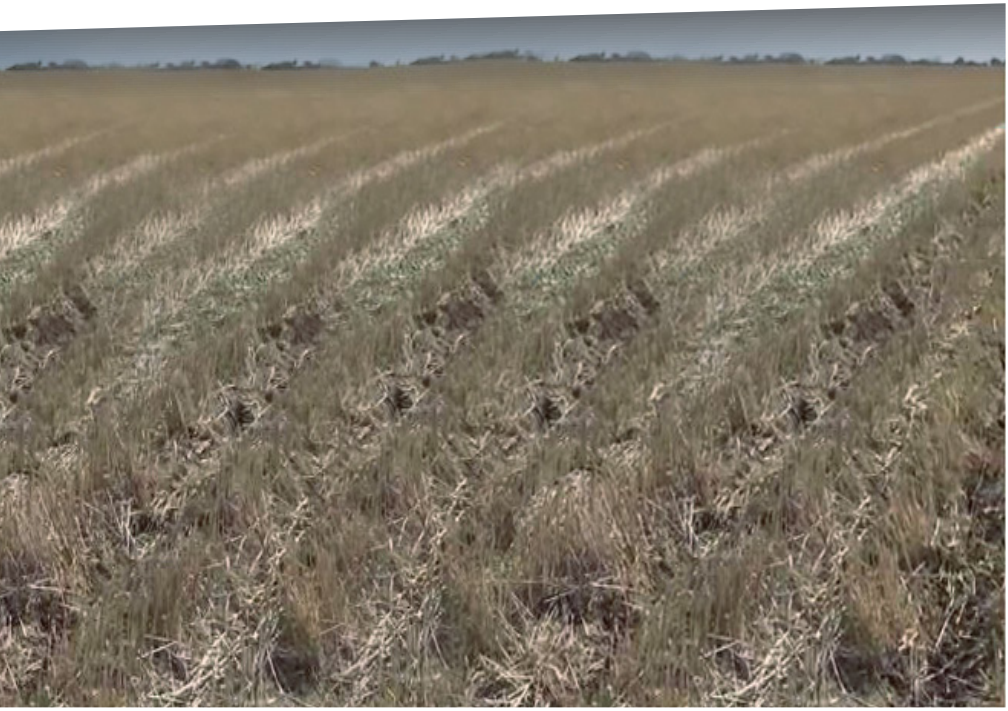
commended management practices such as:

- soil removal and the presence of residue cover/stubble
- crop rotation
- strategic nutrition
- efficient and responsible management of the agrochemicals
- weed control
- integrated pest management

Intensive crop rotations with wheat, rye, barley and maize, improve the carbon content and the structural stability and protect the soil from water and wind erosion.

Impact/Outcome

Some analyses performed by the National Agricultural Technology Institute (INTA) showed that the mixed systems based on both agriculture and livestock increased between 13-19% the total carbon per hectare in the 25 cm of soil profile.
Sustainable agriculture requires more convenient rotations. To keep wheat in the seed sequence or to use cover crops, with winter grass pasture or, depending on the region, using rye, oats, corn, barley or sorghum, greatly improves soil quality.



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