Feasibility analysis for renewable energy in farming in Kosovo

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1 Introduction
IADK is established in 2004 with headquarter Mitrovica, engaged with its activities in the rural development, for improving the socioeconomic conditions in rural areas, reducing employment and imports, production of health food, rational utilization of human resources and environment protection. IADK is in close cooperation with Kosovo farmers and associations, other NGO, municipalities, government institutions, through focusing in diversity activities.

This organization contents a professional team, main goal is to develop farmers production capacity, to increase competitiveness, to deliver to farmers good agricultural practises in production and in small scale processing, lobbying for projects and polices for rural development in Kosovo based in EU Standards.

There are many reasons why are IADK looking towards renewable energy sources. Renewable energy sources show significant promise in helping to reduce the amount of toxins that are by-products of energy use. Not only do they protect against harmful by-products, but using renewable energy helps to preserve many of the natural resources that we currently use as sources of energy.

The price of oil in the last decade has raised to records highs and this has a major impact on the price of food. Renewable energy includes generation of power to do a number of farms tasks: pumping water for irrigation, lighting buildings and others. These forms of renewable energy include solar energy, wind and power water, oils from plants, biogas (gas produced from fermentation of manure and crops residues).

2 Objective of the Consultancy
The following main objectives are considered by this consultancy:

- Feasibility analysis for renewable energy in farming; Identification and conducting a feasibility analysis of potential sources of renewable energy in agriculture, horticulture and small-scale food processing in Kosovo.
- Development of suitable technical solutions on the four options including on piloting the feasible renewable energy options.

3 Outcomes
The main output expected from the consultancy is an assessment of the feasibility analysis for renewable energy, in particular (or: including) solar and photovoltaic energy for farmers needs in Kosovo.

4 Present energy situation in Kosovo
4.1 Energy police
The conflict over the past decades has significantly weakened the country and suppressed development. Kosovo attempt to join the EU, which pose high challenges for the country.

The increasing demand for energy along with the environmental problems associated with today's energy production, call for new steps to be taken. The main energy production in Kosovo is provided by two coal-fired power plants with outdated technology, causing excessively high levels air pollution. Beside the environmental problems, electricity shortages are a major problem. Regular power cuts, lasting several hours, are a daily occurrence. Renewable energy resources are practically untouched.

The Government is aware of the importance of energy policy changes as already illustrated in the "Energy strategy of Kosovo", published in 2005 [1]. One of the main strategies highlights the need to improve the conditions for private investment in the renewable energy sector, in order to increase their share of total production. A publication by the Ministry for Envi-
environment states that the promotion of renewable energies in Kosovo is one of the main strategies for environmental improvement [4.]. New feed-in tariffs for renewable energies (excluding large-scale hydropower plants and solar energy) are being fixed in 2011 by the Energy Regulation Office as shown in . Although the country has no experience with feed—in of electricity and because of frequent power cuts till now it is not possible in reality to generate electricity in a commercial way.

Table 1: Feed-in Tariff applicable for electricity produced from renewable energy sources [5.].

<table>
<thead>
<tr>
<th>Primary renewable energy source</th>
<th>€/MWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>HPPs (&lt;10MW)</td>
<td>63.3</td>
</tr>
<tr>
<td>Wind</td>
<td>85.0</td>
</tr>
<tr>
<td>Solar energy</td>
<td>j/a</td>
</tr>
<tr>
<td>Biogas and Biomass</td>
<td>71.3</td>
</tr>
</tbody>
</table>

4.2 Electricity production
Kosovo’s main provider and producer of energy is the local operator KEK. The two lignite power plants of KEK produce 98% of the electricity used in the country with a total installed power capacity of 2000 MW. It is foreseen to disconnect these two out-dated plants from the grid in 2024, and replace them by a new plant in 2014. The main concern in the energy sector is the shortness of supply leading to regular power cuts, together with the environmental degradation related to the operation. To meet the increasing demand for energy (a 25% increase in annual consumption is foreseen until 2020), new sources of power production must be developed.

Until now, the country is still in the beginning of the exploitation of its renewable resources for energy. Only few small size hydropower plants are installed with a total annual production of roughly 50’000 MWh. So far, only 5 small-size wind turbines (second hand) have been installed but they are not in operation.

4.3 Energy source for heating (wood and lignite)
The main energy source for heating in Kosovo is wood and lignite. Kosovo’s total forest area is estimated at 464 800 hectares, or around 42% of the land area. Some of 278 880 hectares are in public ownership, whereas 185 920 hectares are in private ownership. The total standing volume on public forests is estimated to be around 33.5 million m$^3$, whereas in private forest around 19.5 million m$^3$. The gross annual increment is estimated in 1.3 million m$^3$. The mean annual increment per hectare is 3.0 m$^3$ per year. The annual allowable cut is estimated at 900 000 m$^3$. The reserves in public forests are made up of approximately 56% firewood and 44% technical wood. In private forests, mostly low forests, the respective forests are 46% technical wood, and 54% firewood [12.], [11.].

It is important to mention that around 50% of Kosovo families (which is around 168 000 families) use firewood regularly. According to available data an average of 5 m$^3$ is required annually per family. Therefore the total family needs for firewood is 837 500 m$^3$ annually. Currently, wood is used only for heating purposes, direct burning for cooking and hot water preparation.

Kosovo forests are predominantly broadleaf (oak and beech), created through natural seeding. Only around 5% is classified as coniferous (white pine, black pine etc.) [11.].
5 Available renewable energy sources

5.1 Potential of solar energy

The meteorology of Kosovo is influenced by continental climate with very hot weather in summer month where temperatures can riche 40°C and cold weather in winter session. Temperature can fall during winter to -25°C.

The global radiation per year amount to 1400 kWh/m²·a in Pristina. Variation in radiation within the country is between 1200 and 1500 kWh/m²·a. As the global radiation in average is 23% higher as the average city in Europe the region is suitable for use of solar energy.

Fig. 1: Global radiation in kWh/(m²·year) of Kosovo – horizontal inclined plan [1.]

Fig. 2: Comparison of monthly global radiation between Basel (CH) and Pristina ( + 23%) [2.]
5.2 Wind energy
The Swiss NEK Umwelttechnik AG has carried out a study on wind potential in Kosovo. Ten sites were selected for the installation of measurement equipment. Generally, it can be said, that the average wind speeds within the country are considerably low, due to the topographic location of the country. Though, at higher altitudes, several sites with sufficient wind speeds for wind energy projects have been identified [8]. Like for other renewable energy technologies the use of wind energy depends also on the possibility to feed electricity into the grid. As this is not possible till now the only option will be off-grid solutions in remote areas most likely in the mountain regions. Some wind turbines are already installed in the region of Pristina airport but they are not in operation.

5.3 Biofuel
Currently there is no bio-fuel and bio-ethanol production in Kosovo. However, it is worth to emphasize that there is very limited potential for cultivating energetic crops and for the use of biomass for bio-fuel production. The main reasons for this are:

- High density population of Kosovo;
- Limited agricultural area;
- Small size farm (average of farm size is around 2.2 hectares, but fragmented in 8-10 plots);
- Dependence on agriculture (around 60% of population is living in rural areas, and most of them have no permanent job, so they relay in agriculture to create incomes, these are so called subsistence farmers) [11].

5.4 Biogas
As already described in capture 5.3 potential for biogas in Kosovo is also limited. There are currently limited farmers with maximum size of in average 20 cows per farmers in Kosovo. Therefore it is limited potential for electrification of biogas in an economical way. In order to achieve short payback periods of 3 to 5 years an attractive feed in tariff is necessary similar as in Germany with currently 140 €/MWh and the size of the farm must be at least 100 cows. An individual economic calculation for decision making is necessary.

If feed in to the grid with attracting tariff is not possible the biogas can be used for space heating and for powering small scale gas generator during power cuts. 5 cattle's produce approximately 2500 m$^3$ biogas per year which is 250 kWh for heating. To get a significant contribution of at least 30% of biogas to the energy need for space heating and hot water production at least 60 cows are necessary in a single family house. The minimum energy need for space heating in a single family house will be approximately 15000kWh per year (see also [9]). For 1 kW-electric power installation 2500 m$^3$ biogas per year is necessary for an economic operation. For an efficient biogas production beside cow dung green biomass (e.g. corn, grass...) and a temperature of 35°C to 42°C is necessary. For further technical details see also capture 6.4 and 7.3.2.

6 Potential renewable energy techniques

6.1 Solar water heater (SWH)
SWH work only with direct radiation but can also operate during winter month if sun shine is enough. If the storage tank is filled with hot water of up to 90°C by the sun the hot water can stay hot for 2 to 3 days depending on the quality of storage tank insulation. A standard solar water heater with 4 to 6 m$^2$ collector area and a storage tank capacity of 300 litres can provide 60% of total hot water consumption in a single family house with 4 persons.
Solar water heaters always need a backup heating system for the time sun is not enough. The backup heating system can be an electric rod or it can be connected to the existing boiler, usually powered by wood or coal in Kosovo.

In agriculture solar heat can be used for cleaning but also for milk and fruit processing. Projects on milk pasteurisation with solar water heater exist already e.g. at Emmi AG in Switzerland (see also http://youtu.be/F4EIRTqiOq0?hd=1).

Use of solar collectors for space heating is only an option if energy consumption is already limited by proper insulation of building and windows. In Kosovo there is a high demand for insulation of buildings and therefore use of solar energy for space heating is not on priority in this country.

There are three different types of SWH with different comfort, quality and investment cost available on the marked in Kosovo. Table 2 gives an overview of this SWH with advantage and disadvantage. In capture 0 and 6.1.2 explanation of basic functions can be seen.

At present there are only a few dealers of SWH available in Kosovo. From Europe Sonnenkraft (local provider: http://www.mugacompani.com) and Vaillant offering forced circulation systems (Fig. 3). Currently no provider of pressurized thermosiphon solar water heaters (Fig. 4) from e.g. Greece or Turkey is known in Kosovo. A few dealers offering thermosiphon solar water heater from China (Fig. 5).

Table 2: Overview of different types of SWH.

<table>
<thead>
<tr>
<th>System type</th>
<th>Advantage</th>
<th>Disadvantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forced circulation SWH (see Fig. 3)</td>
<td>• Low maintenance</td>
<td>• No operation during and after power cut.</td>
</tr>
<tr>
<td></td>
<td>• Compatibility with pressurized water installation.</td>
<td>• High investment at approx. EUR 30000.-</td>
</tr>
<tr>
<td></td>
<td>• Freezing protection also under harsh winter climate.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Storage tank can be installed next to the user.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• High comfort</td>
<td></td>
</tr>
<tr>
<td>Pressurized thermosiphon SWH (see Fig. 4)</td>
<td>• Low maintenance</td>
<td>• Low comfort because of frozen pipes from SWH to house.</td>
</tr>
<tr>
<td></td>
<td>• Operation without electricity.</td>
<td>• High energy loses in winter month.</td>
</tr>
<tr>
<td></td>
<td>• Active antifreeze protection possible.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Compatibility with pressurized water installation.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Investment approx. €1000.</td>
<td></td>
</tr>
<tr>
<td>Non-pressurized thermosiphon SWH (see Fig. 5)</td>
<td>• Stainless steel and glass, therefore no corrosion.</td>
<td>• Frequent Maintenance needed because of scaling in collector.</td>
</tr>
<tr>
<td></td>
<td>• Operation without electricity.</td>
<td>• Low comfort because low water pressure</td>
</tr>
<tr>
<td></td>
<td>• Very low investment (approx. €400.-).</td>
<td>• Low comfort because of frozen pipes from SWH to house.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Unusual installation of storage on the roof.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• High energy loses in winter month.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• No active freezing protection</td>
</tr>
</tbody>
</table>
6.1.1 Forced circulation systems

Fig. 3 shows the basic function of a SWH with forced circulation system. Solar collectors (2) absorbing solar radiation. This radiation will be transformed to heat and will be than move on a water / glycol mixture through a piping system to the storage tank (1). The water glycol mixture is used in order to prevent damage by freezing. It circulates by a circulation pump (3) between the collector and the heat exchanger (4) of the storage tank whenever the temperature on the collector is higher as in the storage tank (1). The operation of the pump is controlled by a controller with two thermo sensors on the collector and on the storage tank.

Fig. 3: Basic function of a solar water heater with forced circulation.

6.1.2 Thermosiphon Solar Water Heater

Thermosiphon systems are using natural convection and work without controller and pump. There are two different types of thermosiphon SWH available. The pressurised SWH has closed collector loop where antifreeze can be filled in the flat plate collector (see Fig. 4). They resist pressure up to 6 bar. This type is mainly produced in Greece and Turkey.

In the non-pressurised thermo - siphon SWH (Fig. 5) water is flowing directly through the open vacuum tubes collector. This SWH can only work without pressure und needs overhead tank for filling. It is cheapest option and manufactured in China. Quality standard is often poor. Scaling in the collector must be considered in the maintenance process and the collector cannot be protected against freezing.

- Solar radiation is heating the water in the collector.
- Hot water in the collector has a lower specific density than the cold water in the storage tank and is ascending.
• Cold water from the storage tank has a higher specific density than the hot water in the collector. It is descending.

6.2 Solar air heating
Direct heating of air by solar radiation can be useful for drying purpose or for indoor space heating.
Air is heated on a black surface absorbing solar radiation, which is covered by glass. The hot air is usually transferred by a ventilator in an insulated cannel made by wood or metal sheet. There are professional air-collectors (Fig. 6) as closed units available on the market (e.g. Grammer Solar; www.grammer-solar.com). Fig. 7 shows an fruit dryer with recirculation of air and 15 m² collector surface. The maximum drying capacity is 70 kg row fruits. The Austrian company CONA (www.cona.at) provides readymade solar dryer.
Air collectors can also be used for space heating as part of the construction of houses as shown in Fig. 8.

Advantage of air collectors:
• Realisation with low investment possible
• Reliable and simply technique

Disadvantage of air collectors:
• Heat storage with air is limited

Fig. 6: Solar air collector with integrated ventilator and power supply with photovoltaic panel (Source: Grammer Solar;, Germany).

Fig. 7: Air collector for fruit drying.

Fig. 8: Integrated air collector for space heating.
6.3 Solar electrification

Photovoltaic (PV) panels are used for generating electricity from solar radiation. Compare to solar collectors for water heating photovoltaic panels can produce electricity also with diffuse radiation at clouded weather.

On a roof surface of 100 m² a photovoltaic system of 13 kW can be installed. The yearly production comes to about 120 kWh per year and per m² electricity for the Kosovo region. The investment is at about 3000 EUR per m² installed photovoltaic system.

PV is generally used for feed in to the national electricity grid in Europe but also for off grid solutions where no electricity is available for e.g. basic lighting or irrigation. As currently no feed in of electricity in to the national grid is possible in Kosovo only off-grid installations in remote areas are useful. Off-grid installations, so called Solar Home Systems (SHS) need batteries for storage of electricity in order to provide lighting in evening hours. SHS can also provide electricity for any other electric device including 220V AC equipment’s (TV, PC, radio…) if a DC-AC inverter is installed (Fig. 9). The installation must consider specific DC technique for wiring, connection and switches. As life time of batteries are limited and off-grid installations usually are made in poor remote areas this installations need a long-term planning on service and maintenance for financing the batteries.

Using photovoltaic panels for operating water pumps for irrigation (Fig. 10) can also be useful in the agriculture sector. No batteries are necessary and therefore maintenance is less important compare to SHS. Currently fuel and electricity is used for powering pumps for irrigation. A electric water pump powered by solar electrification with a water capacity of 20 m³ per day (at 8 m deep ground water level) will be between € 3000.- to € 5000.-. The PV panel for this system will be 350 W. The price not includes cost for a reservoir or drip irrigation system.
6.4 Biogas fermenter
As currently no large biogas installations (Fig. 11) considered because Kosovo is dominated by small farmers, only small biogas systems with modification of existing septic tank can be considered.
In order to use a septic tank for fermenter some additional installations are necessary. For keeping the temperature constant the septic tank must be insulated with at least 5 cm e.g. polyurethane hart form. For production of biogas during winter session an additional heating system must be installed on the inside floor or wall of the fermenter, simply using plastic piping equal of a floor heating system (Fig. 12). The energy source for heating the fermenter should be biogas but can be supported by solar energy in autumn and spring month as well. In order to prevent unequal distribution of liquid and solid substrate a mixer with automatic operation is also necessary. The fermenter must be covered to collect the biogas [10.].
For electricity production a generator powered by natural gas in small size is necessary, mainly available on the Asian market for reasonable price. For first sizing of a biogas system see also capture 5.4.
Fig. 11: Biogas system in agriculture (Source: Fachagentur Nachwachsende Rostoffe, Germany).

Fig. 12: Heating system of a fermenter of a biogas system [10.].

6.5 Heat pump
The principal technique of heat pump systems is the same like the compressor in a cooling machine like it is already in use in agriculture by e.g. cooling of milk. A heat pump can lift heat from low temperature (0°C to 30°C) to a temperature up to 55°C and can then be used for space heating and hot water production. A heat pump needs approximately 1 kWh of electricity to produce 3 kWh of heat. The basic function is explain in Fig. 13. The outlet heat of the compressed cycle e.g. from cooling milk (Fig. 13, No. 1) is usually connected to a heat exchanger in order to get rid of the heat. This heat exchanger can be connected with a hot water tank. The installation makes only sense if low temperature heat is available all the year around for hot water like in cow farm houses. If a heat pump for space heating will be used 20 cattle's give about 10 kW low temperature in a closed hall which needs to transfer to 20°C room temperature.
1. Condenser coil (hot side heat exchanger, gas cools and liquefies)
2. Metering Device (liquid expands and cools)
3. Evaporator coil (cold side heat exchanger, liquid vaporizes and heats up)
4. Compressor (gas is compressed and heats up)

Red = Gas at high pressure and very high temperature
Pink = Liquid at high pressure and high temperature
Blue = Liquid at low pressure and very low temperature
Light Blue = Gas at low pressure and low temperature

Fig. 13: Basic function of a heat pump system [6.].

7 Situation Analysis and Recommendations

Table 3: Overview of different renewable energy technology and there application in agriculture.

<table>
<thead>
<tr>
<th>RE-Technique</th>
<th>Agriculture sector</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar water heating</td>
<td>Milk-, Fruit processing, chicken farms (butcher)</td>
<td>Pasteurisation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Improving hygienic (Cleaning)</td>
</tr>
<tr>
<td>Solar air heating</td>
<td>Fruit- and herbal drying.</td>
<td>Pre-heating of air</td>
</tr>
<tr>
<td>Photovoltaic</td>
<td>Small, remote farming without grid connection.</td>
<td>Off grid electrification in rural areas for lighting.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Water pump from well</td>
</tr>
<tr>
<td>Wind</td>
<td>Small, remote farming without grid connection.</td>
<td>Off grid situation rural areas.</td>
</tr>
<tr>
<td>Biogas</td>
<td>Cattle farms with more than 20 cows.</td>
<td>For Heating and cooking, electric generator.</td>
</tr>
<tr>
<td>Biomass</td>
<td>Fruit and herbal drying</td>
<td>Fruit stones as energy source for dryer.</td>
</tr>
<tr>
<td></td>
<td>Heating of green houses</td>
<td>Plant remains for heating green house.</td>
</tr>
<tr>
<td>Biofuel</td>
<td>Transportation</td>
<td>Backup generator, tractor</td>
</tr>
<tr>
<td></td>
<td>Electric generator</td>
<td></td>
</tr>
</tbody>
</table>
7.1 Soft Fruit processing

7.1.1 Pasteurization of fruits and vegetables

Three small enterprises with fruit processing units outside of Mitrovica have been visited for analysing energy consumption and the possible use of renewable energy. One of the companies (TAFA) uses a 500 litre duplicator, the second one a 300 litre unit and the third one did not has a duplicator at all but used an wood oven for fruit processing. TAFA produces with the 500 litre duplicator 1242 kg of marmalade per year.

The fruits are boiled on 130°C in the duplicator for 3 to 6 house. After this the fruits are filled in glasses with a filling pump. The filled and closed glasses are than put in the pasteurisation box and they are going to be headed again on 80°C for 60 min.

After natural cooling marmalade glasses are packed with paper carton. Plastic foil is shrinking around by electric heaters.

Duplicators and pasteurisation boxes are powered also by electricity. The 300 litre duplicator as well as the pasteurisation units have connection for external water heating. The 500 litre duplicator did not have connection for external heating.

According to energy and cost calculation the energy cost amount to 7,30 EUR per patch. Considering a price for row fruit material of 0,30 EUR per kg energy cost of 500 kg fruits amount only to 5 % of the total expenditure.

Currently there is no hot water available for cleaning in the factory.

Energy and cost calculation of marmalade processing per patch:

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Power (kW)</th>
<th>Run time (hours)</th>
<th>Energy (kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duplicator</td>
<td>24</td>
<td>3-6</td>
<td>108</td>
</tr>
<tr>
<td>Pasteurisation unit</td>
<td>10</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>Filling pump</td>
<td>0.75</td>
<td>1</td>
<td>0.75</td>
</tr>
<tr>
<td>Packaging machine</td>
<td>3</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total Energy consumption</strong></td>
<td></td>
<td></td>
<td>121.75 kWh</td>
</tr>
<tr>
<td><strong>Total Energy cost per day</strong></td>
<td></td>
<td></td>
<td>7.305 €</td>
</tr>
</tbody>
</table>

Electric tariff: 0.06 €/kWh
**Recommendation**

Currently electricity costs contribute only to a small level to production cost. Permanent heating the whole process by solar water heater is difficult due to high temperature of more than 100°C in the duplicator but also because of missing connection at the 500 litre duplicator. Hot water from a SWH can be used to fill duplicator and pasteurisation box already with 60°C to 80°C and run the existing electric heater for processing on 130°C. The hot water from SWH can also be used for cleaning as currently no hot water is available.

Long-term dissemination of SWH in the marmalade production with forced circulation will be difficult as investment of this SWH type are high compare to energy saving. As the SWH is only in use in summer optional a non-pressurized thermosiphon SWH can be installed with lower investment of approx. 700.- EUR. Payback time can be than reduced to 7 years. Thermosiphon SWH can be recommended specially for the smaller manufacturer as more maintenance needs to be considered.

<table>
<thead>
<tr>
<th>Installation</th>
<th>Solar collector: 4-5 m² with storage tank: 300 - 500 L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investment</td>
<td>€ 3000.- for forced circulation SWH</td>
</tr>
<tr>
<td></td>
<td>€ 700 .- for non-pressurized thermosiphon SWH.</td>
</tr>
<tr>
<td>Energy saving</td>
<td>1600 - 2000 kWh/a or 100 €/year</td>
</tr>
<tr>
<td>Payback period</td>
<td>30 years (forced circulation SWH)</td>
</tr>
<tr>
<td></td>
<td>7 years (non-pressurized SWH)</td>
</tr>
</tbody>
</table>

Fig. 17: Forced circulation system with 300 Litre storage tank and 4 m² collector area.

For beginners in the fruit processing business solar box as shown in Fig. 18Fig. 18: Solar box useful for pasteurization of small amounts in summer month. could be an alternative to conventional cooker.

Fig. 18: Solar box useful for pasteurization of small amounts in summer month.
7.1.2 Fruit and herbal drying

7.1.2.1 Large scale drying (herbal) at central dealer
One of Kosovo main producer of herbal products is Agroprodukt Syne. The company produces 120 tons of dried flowers and fruits mainly for export to EU countries.
The company use a floor dryer (Fig. 19) as main drying unit. The drying material is put on the floor while air is passing through a grid into the material. An automatic rake circulates through the drying material in order to mix it to an equal condition of humidity. Energy source comes from a type of pellet oven feed by cherry stones. The cherry stones are from Serbia available on a very low price of € 10.- per 100 kg. With 100 kg of cherry stones the dryer can be powered for 24 hours, which is about the drying time for wild apples. The capacity of the dryer is about 1.5 tones depending on the material. The dryer is manufactured by Termopl in from Mladenovac (Serbia). The big advantage of the floor dryer is the easy loading process of the dryer as well as filling of dried material in to bags in short time.

Fig. 19: Floor dryer powered by cherry stones.

A cabinet dryer powered by wood and with drying trays has an inefficient combustion of wood and produce poor quality. It will be therefore considered according to the manager to be replaced soon. The new design will be a dryer with hot water to air heat exchanger and external wood boiler.

Fig. 20: Rose hips on drying trays ready for drying.

Recommendation
As drying temperature is not more than 70°C a solar water heater, respective air collectors can be implemented in the dryer design. Before implementation of solar energy unit in a dryer the dryer must be checked for an energy efficient operation with recirculation of hot air according to saturation of the drying products and proper insulation of the drying chamber.
In order to improve drying quality it is important to have limited time between harvesting and drying of the material. Therefore it is in plane to implement decentralised dryer with capacity of 200 to 750 kg in future. For these new dryers the use of solar energy as energy source will be considered. The local manufacturer of dryer Termoplín is already requested for a solar dryer design and proposal for design was send to this company in September 2012 by the consultant. In case Termoplín will be not able to deliver an solar dryer it is recommended to invest in a first test dryer from Austrian company CONA.

For the existing floor dryer at is Agroprodukt Syne an air collector area of 60 m² could be mounted on the roof to preheat the inlet air of the dryer by solar energy. As cherry stones currently represents a very cheap energy source, solar collectors are only cost efficient if the investment is low. This could only be made by local production of an air collector roof instead of import of air collectors from e.g. Germany.

Alternatively the new planned dryer at is Agroprodukt Syne with hot water circulation can be preheated by a solar water heater. On this new dryer wood will be substituted which is more expensive. A draft of a hydraulic schema is shown on Fig. 21. With the 3-way valve U1 solar heat can be provide either direct to the dryer via the oil boiler oder can be stored in the tank. The 3 way valve U2 will bring the back flow either in the storage tank if temperature is low or if back flow temperature is higher as in the tank U2 will bass the tank.

A solar water heater with collector area of 50 m² can produce 27'500 kWh per year. From total energy cost (wood) per drying process of EUR 30.- saving by solar energy will be EUR 9.-.

The investment of the 50 m² solar water heater including the storage tank of 1000 litre will be € 21'000.-. The payback time will be at 16 years and will be therefore not attractive for further multiplication under current energy costs. The economic calculation considers an estimation of 150 drying processes per year. Because of the uninteresting payback time a simply air collector on the air inlet will be recommended even for this dryer as recommended in next capture 7.1.2.2.

<table>
<thead>
<tr>
<th>Flat plate solar collector</th>
<th>50 m² and 1000 litre storage tank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investment</td>
<td>€ 21.000.-</td>
</tr>
<tr>
<td>Energy saving</td>
<td>9 € per day of 30 € wood</td>
</tr>
<tr>
<td>Payback time</td>
<td>16 year (considering 150 uses per year)</td>
</tr>
</tbody>
</table>

![Hydraulic schema](image)

Fig. 21: Large scale solar water heater for preheating wood dryer.
### 7.1.2.2 Large scale drying (fruits) at central dealer

At the fruit dealer in Mitrovica a new cabinet dryer with drying trays was installed in 2012. The dryer can produce 1 ton of dried plums in 24 hours with an energy consumption of 1 m$^3$ wood. Energy cost from wood burning will be € 30.- per m$^3$ and per drying process.

![Fruit dryer in Mitrovica with drying capacity of 1 tone and wood as energy source.](image)

**Fig. 22:** Fruit dryer in Mitrovica with drying capacity of 1 tone and wood as energy source.

#### Recommendation

A simply installation of an air collector area of 50 m$^2$ on the roof of the building and pre-heating the inlet air pipe to already 50 to 60°C as shown in Fig. 22 will be recommended for reducing energy consumption from wood by 25% per drying process.

For installation of an air collector from Grammer Solar (www.grammer-solar.com), Germany € 18'000.- must be considered. A realistic payback period is not possible with this investment. For a local made air collector with black metal sheet covered by glass with estimated investment of € 5'000.- payback time of 4 years are possible if the dryer is 150 days per year in use.

<table>
<thead>
<tr>
<th>Additional solar air collector</th>
<th>For existing 1000 kg wood dryer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investment</td>
<td>€ 18,000.- with import from D or A</td>
</tr>
<tr>
<td></td>
<td>Local made collector with 5000.- 8000.-</td>
</tr>
<tr>
<td>Energy saving per year</td>
<td>24'000 kWh or € 1000.- (considering 150 uses per year)</td>
</tr>
<tr>
<td></td>
<td>25% per process</td>
</tr>
<tr>
<td>Payback</td>
<td>15 years (local production will reduce payback time)</td>
</tr>
<tr>
<td></td>
<td>4 year</td>
</tr>
</tbody>
</table>

#### 7.1.2.3 Decentralised drying of fruits with smaller dryer

Seven collection points with dryer similar as shown in Fig. 23 exist under the support of IADK in Kosovo. The cabinet dryer is powered by electricity and energy cost amount to about 10% of the total production costs. Currently the income from fruit and herbal drying for the owner comes to € 45.- per drying process. If the electric energy consumption can be substituted 90% by solar energy the income will rise for 30%.

As electricity tariff in future will most likely rise drying by electricity will be a risk for the income of small farmers in Kosovo. The substitution of electricity by solar energy will be there for an important step to sustainable development.
Fig. 23: Cabinet dryer with capacity of 300 kg row material at regional collection point outside of Mitrovica.

Cost calculation for single drying patch

<table>
<thead>
<tr>
<th>Item</th>
<th>Amount</th>
<th>Cost (€/unit)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purchase of 300 kg row material for</td>
<td>-90</td>
<td>(0.30 €/kg)</td>
</tr>
<tr>
<td>Sales of 150 kg dried material for</td>
<td>150</td>
<td>(1.00 €/kg)</td>
</tr>
<tr>
<td>Electricity 10 kW for 24h: 240 kWh</td>
<td>-15</td>
<td>(0.06 €/kWh)</td>
</tr>
<tr>
<td><strong>Farmer Income per day</strong></td>
<td></td>
<td><strong>45</strong></td>
</tr>
</tbody>
</table>

**Recommendation**

As already recommended in capture 7.1.2.1 air collectors can be used for preheating the drying process. Solar dryer can be provided from a manufacturer from Austria. For sustainable implementation and in order to provide service and maintenance on the dryer local product from e.g. Thermoplin should be preferred.

As already mentioned in 7.1.2.1 the company Thermoplin was already contacted for designing a solar powered dryer.

<table>
<thead>
<tr>
<th>Solar dryer capacity</th>
<th>250 kg</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Investment</strong></td>
<td>17,000 € (if import from Austria)</td>
</tr>
<tr>
<td><strong>Payback time</strong></td>
<td>8 year (considering 150 uses per year)</td>
</tr>
<tr>
<td><strong>Local production reduce payback time</strong></td>
<td></td>
</tr>
</tbody>
</table>

For first pilot installations a dryer based on heat pump technology would be also of interest especially for drying of medical herbals because with this dryer the material will keep aromatics better and therefore product quality will improve essential. The dryer will heat the material in a closed room as well as condensation of humidity will be in this room. Energy consumption will be reduced by 60% compare to existing electric dryer.

<table>
<thead>
<tr>
<th>Heat pump dryer</th>
<th>250 kg for medical herbals</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Investment</strong></td>
<td>13,000 € (import from CH + local assembling)</td>
</tr>
<tr>
<td><strong>Energy consumption</strong></td>
<td>2.2 kW instead of 10 kW electric</td>
</tr>
<tr>
<td><strong>Payback time</strong></td>
<td>7.5 year (considering 150 uses per year)</td>
</tr>
</tbody>
</table>
7.2 Horticulture

7.2.1 Greenhouse

Greenhouses in Kosovo need additional heating, in most cases by wood during winter session around Christmas till 15\textsuperscript{th} March. The heating purpose is mainly for seedling of tomatoes and paprika.

In very cold days seeds will be covered with an additional plastic cover, therefore the temperature at the seeds will be at 18°C and in the greenhouse it will be 4°C at an outside temperature of – 15°C.

Small additional measures can be taken as insulation of heating pips between single greenhouses (Fig. 24). Fig. 25 shows piping material with poor heat transfer which will reduce efficiency and increase energy cost.

![Insulation of heating pipes between single greenhouses.](image1)

![Piping material with poor heat transfer will reduce efficiency and increase energy cost.](image2)

Energy cost per winter session for seedling in greenhouse:

<table>
<thead>
<tr>
<th>Description</th>
<th>Value 1</th>
<th>Value 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>wood boiler 1</td>
<td>100 kW</td>
<td></td>
</tr>
<tr>
<td>wood boiler 2</td>
<td>200 kW</td>
<td></td>
</tr>
<tr>
<td>energy consumption per heating session</td>
<td>60 tone cook</td>
<td>30 €/tonne</td>
</tr>
<tr>
<td></td>
<td>65 tone wood</td>
<td>30 €/tonne</td>
</tr>
<tr>
<td>electricity for circulation pump</td>
<td>432 kWh</td>
<td>0.06 €/kWh</td>
</tr>
<tr>
<td>energy cost per winter session</td>
<td>€ 3776.-</td>
<td></td>
</tr>
</tbody>
</table>

**Recommendation**

Wood boiler should be always in the greenhouse and not next to the greenhouse in order to use also the heat losses from the boiler.

Inefficient, old circulation pumps should be replaced by energy efficient circulation pumps. The circulation pump should only run if heat is necessary either by time switch or by temperature switch.
Black polypropylene – piping should be used. Piping material with poor heat transfer like shown in Fig. 25 will reduce energy efficiency and increase energy cost.

The plastic cover on the seeds for additional insulation at low temperatures should be used consequently.

Currently several projects on improving greenhouses on energy efficient going on in Germany (see also http://www.zineg.de/?q=en/node/50).

Plant remains should be collected during the year and can be used for heating the greenhouse in the winter month.

Solar energy for heating the green house can be not recommended us the energy need is only in the month where radiation is on the lowest level.

### 7.3 Lifestock

#### 7.3.1 Milk pasteurization

Milk pasteurization at the company ALDI, Mitrovica was investigated for use of renewable energy.

The company heats every day 3000 – 4000 litre milk to 95°C according to Fig. 26. Milk pasteurisation starts at 10:00 o'clock and is finished after 2 hours at 12:00. 60% of the year they use pasteurisation tanks 40% of the year they use heat exchanger for direct heating the milk. Currently 1000 litre of diesel from fuel stations is used for heating the milk. With an oil price of 1.35 €/litre the energy cost amount to EUR 14'700.- per year.

The existing heating system is in a very poor condition. A new oil boiler for replacing the existing boiler is already in store and will be installed soon.

Besides high energy cost for milk pasteurisation the company has problems with low voltage, as the next transformation point is too far away. Therefore electric motors are not working properly.

<table>
<thead>
<tr>
<th>Milk pasteurisation</th>
<th>3000 – 4000 L milk per day to 95°C in 2 hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing energy source</td>
<td>1000 litre diesel per month -&gt; 14700 €/year (l)</td>
</tr>
<tr>
<td>Price per kWh</td>
<td>0.135 €/kWh</td>
</tr>
</tbody>
</table>

Fig. 26: Temperature monitoring of milk pasteurisation on the 24.09.2012 at ALDI, Mitrovica.
Fig. 27: Milk pasteurisation at ALDI, Mitrovica including oil boiler for heating.

**Recommendation**

Because of simultaneity of milk processing and availability of sun energy a solar water heater would significant reduce energy cost. As energy need is only for 2 hours and the afternoon sun is not in direct use design of storage tank must be according to afternoon sun in order to prevent stagnation in the collector and therefore loss of solar energy. In order to minimise storage tank capacity the owner should also be asked if the process can be extended or shifted by at least one hour with process ending at 13:00.

The investment for a 80 m² collector area with 2000 litre storage tank amount to approx. € 35'000.-. Energy saving will be than 48'000 kWh per year with € 6000.- of fuel saving.

In this case the solar water heater will have a payback period of only 5.5 years.

The current temperature difference between inlet and outlet from the pasteurization process is very small with 95/80°C. Therefor solar collectors must work on a very inefficient performance even if vacuum tube collectors are recommended. Further investigations are necessary if the process can be heated by solar to e.g. 70°C first and in a second step with oil to the final temperature of 95°C if pasteurisation tanks are in use. The schema shown in Fig. 28 will give an idea how the combination of high process temperature can be achieved by solar in combination with oil boiler. Before realisation the design needs further investigation on temperature and energy need. The hydraulic design in Fig. 28 is only a draft and needs further specification in detail. A simulation by e.g. Polysun of the installation will be recommended in before.

Roof of the building is very fragmented and piping would be very long because of the height of the building. Therefore the installation of the collector area should be made on the ground behind the main building.

<table>
<thead>
<tr>
<th>Installation</th>
<th>80 m² vacuum tube collectors and 1500 L storage tank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investment</td>
<td>approx. € 33.000.-</td>
</tr>
<tr>
<td>Energy saving</td>
<td>48000 kWh/a (65%); 6000 €/year</td>
</tr>
<tr>
<td>Payback period</td>
<td>5,5 years</td>
</tr>
</tbody>
</table>
In addition to the use of solar energy for heating the surplus of heat from cooling engine can be considered as energy source. As this heat is on a maximum temperature level of 55°C it is difficult for integration in a process, but can be used for hot water production for cleaning.

7.3.2 Cattle farming
A cattle farm with 20 cows for milking was investigated on energy consumption and use of renewable energy outside of Mitrovica.

According to energy calculation cost per day amount to € 6.- mainly for cooling the milk during night, cleaning the cow house and powering the milking machine. With a milk production of 20 cows the farmer can earn about € 40.- per day. Therefore the energy cost amount to 15% of the total earning. The farm is made for at least 40 cows and after extension the energy cost will be a smaller contribution.

The farmer will also dick a hole for a septic tank in near future and he is therefore interested on biogas production. The farmer is interested on a secondary energy source as power cuts are a problem especially at milking time.

Energy and cost calculation per day for milking in a 20 cows cattle farm:

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Power (kW)</th>
<th>Run time (hours)</th>
<th>Energy (kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milking machine</td>
<td>2.5</td>
<td>1</td>
<td>2.5</td>
</tr>
<tr>
<td>Cooling tank</td>
<td>7.5</td>
<td>12</td>
<td>90</td>
</tr>
<tr>
<td>Cleaner with scraper machine</td>
<td>2.2</td>
<td>1</td>
<td>2.2</td>
</tr>
<tr>
<td>Lighting</td>
<td>0.2</td>
<td>12</td>
<td>2.4</td>
</tr>
<tr>
<td><strong>Total energy consumption</strong></td>
<td></td>
<td></td>
<td><strong>97.1 kWh</strong></td>
</tr>
<tr>
<td><strong>Total energy cost per day</strong></td>
<td></td>
<td></td>
<td><strong>€ 6,00</strong></td>
</tr>
</tbody>
</table>

Electric tariff: 0.06 €/kWh
Fig. 29: Cooling tank, milking machine and cows at a farm outside of Mitrovica.

**Recommendation**

If feed in of electricity in the public grid would be possible the farmer could install a photovoltaic system on the roof of his farm and at the same time he could generate electricity from biogas if the number of cows will extended. Because of the exposed position of the farm use of wind energy could also be an option in the future.

Unfortunately feed in to the grid is not possible as already mention before and the farmer can only use the produced energy on his own farm. A photovoltaic system only for backup in case of power cut is not economical therefore only production of biogas for own use could be of interest.

If the farmer extent to 40 cows the farm can produce 20'000 m$^3$ of biogas per year, which is about 20% for heating a single family house. He can than, also consider using the biogas for operating a backup generator in case of power cuts.

The investment for insulation of the septic tank, installation of heating pipes in the tank and cover of the tank plus a mixer will be approx. € 6'000.-. Energy saving from replacing wood for heating will be 3 m$^3$ of wood per year or € 90.-. As the farmer has his own wood the installation is not interesting from financial point of view.

The additional heat from the cooling machine of the milk tank cannot be used in this project, because installation is new but should be considered for new installations at other farms for at least heating the hot water on the farm, which can be used for cleaning.

| Investment for biogas production in septic tank | € 6’000.- |
| Energy saving | 3 m$^3$ wood or € 90.- per year |
| Payback period | 66 years |
8 Next steps and final recommendation

According to the study made in this project solar energy can provide an interesting contribution in the agriculture sector of Kosovo in order to reduce running cost and in order to make steps forward to further sustainable development. The use of solar energy can be interesting if expensive fuel e.g. diesel at milk processing can be saved. It also can be of interest if investment cost are moderated e.g. with air collectors in herbal drying processes.

Because renewable energy sources cannot feed the electricity in to the grid photovoltaic, wind energy and biogas production cannot be seen interesting from the economic point of view. Also for producing biogas large agriculture areas are necessary which are not available in Kosovo.

Projects with potential of multiplication, also without financial support and moderated payback times of approximately 4 years can mainly be see in milk processing as shown in capture 7.3.1.

Further recommendation can be made for use of air collectors in herbal drying process. This project must be in cooperation with local supplier of dryer in order to have service for maintenance of the total system. A first air collector for pilot installation can be made by German or Austrian collector supplier.

It seems also interesting for a first pilot installation to realise a solar powered irrigation pump to investigated acceptance and improvement in horticultural production.

Small scale solar water heater can be recommended for fruit pasteurisation. For multiplication by the manufacturer themselves the investment must be low. Therefore only thermosiphon SWH can be recommended for a first installation to investigated acceptance.
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