Thermal Biomass for Lebanon

Mediterranean Mosaics Project (MM)

Shouf Biosphere Reserve (SBR)

2015

Project title:

Mediterranean Mosaics:

strengthening the resilience of Mediterranean landscape to socio-economic and climate change

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Funded By

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Implementation in Lebanon

in Italy

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List of Abbreviations

ACS	Al-Shouf Cedar Society
AFDC	Association for Forests, Development, and Conservation
CC	Climate Change
FAO	Food and Agriculture Organization
GHG	Green House Gases
LCV	Lower Calorific Value
MM	Mediterranean Mosaics
PTO	Power Take-Off
SBR	Shouf Biosphere Reserve
UNDP	United Nations Development Programme

Executive Summary

I. Executive Summary

The ‘Thermal Biomass for Lebanon’ project aims to develop new methods to improve the use of local raw materials in a sustainable way, with a focus on climate change mitigation and adaptation: (i) to promote a climate-resilient and economically viable use of the forest and agriculture biomass whose excessive load or post-harvesting burning by farmers increase climate-related risks in the rural landscape, namely the forest fires that devastate large areas of Lebanon every year; (ii) to contribute to the reduction of CO_2 emissions from fossil energy consumption and the burning of forests and agriculture waste; (iii) to increase the capacity of forest ecosystems to adapt to climate change with a reduced competition for the scarce water resources in the thinned forest stands and healthier forest stands that can store higher quantities of carbon; (iv) to reduce energy cost and increase local employment and local business around energy production.

This project falls under the umbrella of the Mediterranean Mosaics: Strengthening the Resilience of Mediterranean Landscapes to Socio-economic and Climate Change (hereinafter MM) supported by MAVA Foundation to preserve and enhance diversity at all levels – biological, ecological, economical, and cultural - as the best strategy to build the resilience and secure the viability of Mediterranean socio-ecosystems. The MM team is a consortium of partners with solid experience in landscape planning and sustainable natural resources management. In Lebanon, Shouf Biosphere Reserve (SBR), works in partnership with the Association for Forests, Development and Conservation (AFDC). The project also secured the technical assistance of Montaraz Group and lately Sylvestris Group- two Spanish companies with a solid track record in work related to forest biomass and rural development.

The ‘Study of Forest Biomass Sustainability’ by Sylvestris Group SL supports the initiative of the Shouf Biosphere Reserve’s project “Thermal Biomass for Lebanon” to install a new wood and olive pomace briquette production plant for wood stoves used by the inhabitants of the region.

There is currently a small bio-energy plant near Kfarfakoud capable of producing a million briquettes per year. The plant intends to expand to a nearby building, creating more space and introducing mechanization, which will allow for increased production in coming years.

The three components used in producing the briquettes are:

- Woodchips from the forest (45% moisture content at origin).
- Woodchips from agricultural waste (45% moisture content at origin).
- Olive pomace (30% moisture content at origin).

The woodchips represent 43% of the end product and the remaining 57% corresponds to the olive pomace. The briquettes will be sold to the end consumers with 17% moisture content.

Both the woodchips from pruning fruit trees such as apples, peaches, almonds, olives, and stone pines, and the olive pomace from olive oil presses are considered as agricultural waste. According to the information collected there should be no problem maintaining a sustained supply of agriculture waste raw materials every year. Additionally, the economic use of these materials will generate important environmental benefits, namely the abatement of pollution from olive pomace waste disposal, and fire-risk reduction by not burning the tree pruning waste.

However there is a limit to the amount of forest

wood that is available to produce woodchips. The annual production is restricted to the waste produced by the sustainable forest thinning operations in the nearby mountains. The law regulates the amount of wood that can be collected in order to enhance the sustainability of the forest areas.

By improving production of the Kfarfakoud Briquettes Center and sustainably managing the Dalboun Oak Forest to optimize its biomass production the project is helping to prevent forest fires and pollution from agriculture waste, and mitigate the problems caused by the CO2 emissions from fossil fuels and forest fires, while converting waste into an economic and rural development opportunity.

The current project aims to meet three goals:

Social: Promoting entrepreneurship in rural areas to create direct and indirect jobs thereby reducing the migration of rural people to cities.

Environmental: The use of waste wood from forests and fruit tree orchards for bioenergy reduces the risk of fire, pests and forest diseases, and has significant potential to mitigate GHGs if resources are sustainably developed and efficient technologies are applied[1]. The carbon dioxide that emerges from the combustion of biomass is the same as that absorbed throughout its life during photosynthetic activity resulting in a net zero carbon balance (unlike fossil fuel)[2]. In addition the use of agricultural and industrial by-products generates a number of environmental benefits by reducing waste pollution and CO_2 emmissions...

Economic: Any enterprise should look for profitability and the use of forest and agriculture biomass is based on constant growth with positive returns. The main savings will be for customers who switch to biomass.

[1] *Inter governmental Panel on Climate Change [IPCC] (2011) Special Report on Renewable Energy Sources and Climate Change Mitigation: Bioenergy.*

[2] *Smith, K. R. (1994) Health, energy, and greenhouse-gas impacts of biomass combustion in household stoves. Energy for Sustainable Development I Volume I No. 4 I November 1994*

غابات السنديان في حرج دلبون بشكل مستدام. المشروع يضع افقاً لمعالجة هذه المخلفات وتحويلها الى ثروة اقتصادية تنموية مما يسهم في حماية الغابات من الحرائق والتلوث الناتج عن المخلفات والبقايا الزراعية، وكذلك التخفيف من انبعاثات ثاني اوكسيد الكربون الناجمة عن استخدام الطاقة وحرائق الغابات.

يهدف المشروع الى تلبية ثلاثة اهداف:

اجتماعيّاً: خلق فرص عمل جديدة في المناطق الريفية مما يقلل من نزوح سكان الريف نحو المدن.

بيئيّاً: عملية تحويل الفضلات الخشبية والمخلفات النباتية الى طاقة حيوية تسهم في التقليل من خطر الحرائق وانتشار الحشرات الضارة والأمراض في الغابات، وكذلك التخفيف من نسبة الغازات الدفيئة، خاصةً اذا تم تطبيق التقنيات الحديثة بشكل فعال. كما وأن كمية ثاني أكسيد الكربون التي تنتج عن احتراق الكتلة الحيوية هي نفس الكمية التي تحتاجها النباتات خلال نموها مما يعني توازناً في كمية الكربون (على عكس الوقود الأحفوري). فمعالجة المنتجات الزراعية والصناعية واعادة استخدامها يولد كمّاً من الفوائد البيئية ابرزها الحد من تراكم الكتلة الحيوية. هذا بالاضافة الى تخفيف اسباب قطع الغابات لان المشروع سيؤمن البديل بكلفة اقل بكثير.

اقتصاديّاً: مشروع معالجة الفضلات والمخلفات الزراعية هي عملية متجددة ومستدامة ذات نموٍ مستمر وعوائد اقتصادية مربحة لا تقتصر على المنتِج فحسب، بل تشمل ايضًا المستهلك الذي يستخدم هذا الوقود الحيوي لانتاج الطاقة.

I. Executive Summary (Arabic)

يهدف مشروع " ادارة الكتلة الحيوية في لبنان" الى تطوير أساليب جديدة تعزز استخدام المواد الاولية المحلية بطريقة مستدامة لتخفيف آثار التغيرات المناخية وامكانية التكيف معها عبر:

١- استخدام مخلفات الغابات والزراعة بشكلٍ مرن واقتصادي، حيث ان التخلص منها بالطرقً التقليدية المعتمدة يزيد من المخاطر المناخية، وخاصة الحرائق التي تقضي على مساحات شاسعة من غابات لبنان في كل عام.

٢- المساهمة في الحد من انبعاثات ثاني اوكسيد الكربون الناجمة عن استهلاك الوقود، واحتراق الغابات والمخلفات الزراعية.

٣- زيادة قدرة النظم الإيكولوجية للغابات على التكيف مع التغيرات المناخية وبالتالي خفض الضغط على الثروة المائية، مما يساعد الغابات المستصلحة على احتباس كميات أكبر من الكربون.

يندرج مشروع "ادارة الكتلة الحيوية في لبنان" تحت مظلة مشروع "Mediterranean Mosaics" الذي يهدف الى تعزيز المناظر الطبيعية المتوسطية على مواجهة التغيرات الطارئة على الصعد الاجتماعية، الاقتصادية، والمناخية وذلك بدعم من مؤسسة MAVA التي تسعى الى الحفاظ على التنوع البيولوجي، الإيكولوجي، الاقتصادي والثقافي. وهو أفضل استراتيجية لبناء القدرة على التكيف وتأمين سلامة النظم البيئية والاجتماعية لمحيط المتوسط. جميع الشركاء في مشروع "Mediterranean Mosaics" هم ذوي خبرة واسعة في مجالي التخطيط للمناظر الطبيعية والإدارة المستدامة للموارد.

وفي هذا الاطار، تعمل محمية الشوف المحيط الحيوي بالتعاون مع جمعية حماية الثروة الحرجية والتنمية وبدعم تقني من مجموعتي مونتاراز وسيلفزترس الاسبانيتين ذات الخبرة الواسعة في ادارة الكتلة الحيوية والتنمية الريفية.

دراسة سيلفزترس حول "الكتلة الحيوية المستدامة " تدعم الفرضيات التي قدمتها محمية الشوف المحيط الحيوي في مشروع "ادارة الكتلة الحيوية في لبنان" لصناعة حطب للتدفئة من مخلفات الاحراج والزراعة وجفت الزيتون لاستخدامها من قبل سكان المنطقة في تدفئة المنازل. حاليًا يوجد مصنع لصناعة هذا الحطب في بلدة كفرفاقود قادر على إنتاج حوالي مليون حطبة سنويًا. ويتطلع المصنع الى زيادة انتاجه عبر زيادة مساحته وإدخال المكننة.

المكونات الثلاث المستخدمة في انتاج الكتل الحيوية هي:

- بقايا نشارة الخشب من الغابات (45% رطوبة)
- بقايا نشارة الخشب من المخلفات الزراعية (45% رطوبة)
- جفت الزيتون (30% رطوبة)

تشكل نشارة الخشب نسبة 43% من المنتج النهائي، اما جفت الزيتون فيشكل نسبة 57%. هذا المنتج يتم تأمينه للمستهلك النهائي بنسبة 17% رطوبة.

المخلفات الزراعية تشمل اضافةً الى جفت الزيتون، نشارة الاخشاب وهي الفضلات الخشبية المتبقية من عملية تشحيل الاشجار المثمرة كالتفاح، الخوخ، اللوز، الزيتون والصنوبر. ووفقا للمعلومات التي تم جمعها يجب ألا يكون هناك عائق امام تامين هذه المخلفات بحيث ان هناك فوائد بيئية جمة تنتج عن استخدامها كالحد من التلوث والحرائق الناجمة عن الطرق التقليدية المستخدمة للتخلص من مخلفات الزيتون وبقايا الاشجار المقلمة .

ولكن هناك محدودية في كمية الاخشاب المتوفرة لانتاج نشارة الاخشاب، اذ يعتمد الانتاج السنوي على البقايا التي تنتج طبيعيًا من عملية التشحيل المستدامة للغابات والتي يضمنها قانون حماية الغابات في لبنان.

يمكن تحسين انتاج الكتلة الحيوية من خلال تحسين انتاجية المصنع الموجود في بلدة كفرفاقود، وادارة

The Importance of Biomass

2. The Importance of Biomass

The importance of biomass management in the Lebanese policy context

The Lebanese Government has set the strategic goal to achieve a 12% increase in renewable energy by 2020. A National Energy Efficiency and Renewable Energy Action[3] was created in 2014, in the framework of the National Energy Efficiency Action Plan (2011), as a financing mechanism to support environmentally sustainable projects. The spectrum of available technologies envisaged is quite wide, including converting waste biomass into energy.

In 2012, a National Bioenergy Strategy for Lebanon was prepared with the support of UNDP[4], as a fundamental contribution to the Government's goal of achieving a 12% increase in renewable energy. A total of twenty-three biomass streams representing a potential resource for energy production have been identified and fully characterized. Among the ten most promising bioenergy streams are the residues from forest thinning and pruning, from fruit and olive tree pruning, and from olive oil pressing. The selected conversion technologies include the direct thermal decomposition of biomass and the pre-treatment of forest and agriculture residues into briquettes and pellets.

The 2008 Lebanon's National Forest Fire Management Strategy[5], developed in the framework of climate change adaptation and mitigation, proposes the reduction of the overload of forest and agriculture biomass as a fire-risk reduction measure, with the multipurpose objective to increase landscape resilience to climate change impacts (the increase of frequency and intensity of heat waves and drought events, with the consequent exacerbation of uncontrolled fires) and support sustainable rural development and job creation alternatives.

The advantages of biomass

Biomass is a renewable form of energy because, unlike fossil fuels whose deposits are limited, plants grow through photosynthesis by capturing energy from the sun. It is therefore a source of sustainable energy, indigenous, and zero balance in CO2 emissions[6].

Biomass has a number of advantages over other renewable energies:

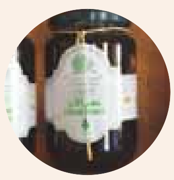
- Continuous supply: Unlike wind, solar and hydroelectric energies, which respond to natural processes that could be interrupted, the supply of biomass can be continuous.
- Employment: Biomass generates 15 times more jobs than fossil fuels and those jobs are mainly in rural areas.
- Potential: Biomass is a renewable energy with real potential because farmers themselves generate it as a result of the waste from the crops they grow.
- Present in all territories: Biomass, whether from agriculture, forestry, marine or urban is present in almost every territory.
- Reduced forest fires: As a potential new source of revenue the forest is valued by the inhabitants of rural areas: the most obvious evidence is that forests providing economic benefits never suffer severe fires.

3 *RCREEE (2014) National Energy Efficiency and Renewable Energy Action (NEEREA).*
4 *UNDP/CEDRO (2012) National Bioenergy Strategy.*
5 *Mitri, G. Ed. (2008) Lebanon's National Forest Fire Strategy. MoE.*
6 *Smith, K. R. (1994)*

Benefits of Biomass compared with other renewable energies

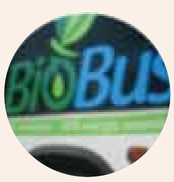
Continuous supply

Employment



Making the Forest more valuable

Available in all the territory



Can be used for transport

Forest biomass in Mount Lebanon

According to data from FAO (2011)[7] Lebanon produces 80,000m^3 of firewood, which are consumed in the country itself. Below is a summary table highlighting the importance of timber for industrial purposes. According to the FAO only 25% of the wood consumed in Lebanon is produced in the country.

The production and consumption of forest production in lebanon

Type		M^3
Firewood	Production	80,000
	Consumption	80,000
Industrial Wood Roll	Production	7,000
	Consumption	45,000
Lumber	Production	9,000
	Consumption	259,000
Wood Panels	Production	46,000
	Consumption	338,000
Paper Paste	Production	-
	Consumption	42,000
Paper & Cardboard	Production	103,000
	Consumption	294,000
Total	Production	245,000
	Consumption	1,058,000

Biomass and rural areas

Rural dwellers in Lebanon make up 13% of the total population[8]. Many of the rural communities are located in mountainous regions where the winters are cold and wet. That is why the consumption of fossil fuels for heating purposes in these areas is much higher than in the milder parts of the country. The rural development policy, therefore, should highlight the use of renewable energy that is produced in the rural areas themselves.

Forests in Lebanon have undergone a process of continuous degradation that has led to their intense fragmentation, a significant loss of ecological integrity and the increased vulnerability of rural communities that depend on forest resources for survival [9].

[7] *FAO (2011) State of the World's Forests*
[8] *Population characteristics in Lebanon, Central Administration of Statistics, 2009.*
[9] *AFDC (2007) State of Lebanon's Forests*

Biomass and employment

The development of **biomass generates up to 15 times more jobs than fossil fuels – at an average of 135 jobs per 10,000 consumers**, compared with 9/10,000 of fossil fuels[10]. It should be noted also that most of these jobs are created in rural areas, which helps to keep the population in these areas and to promote industrial development.

Biomass and forest fires

According to FAO, between 1990 and 1995[11], over 30% of Lebanon's forests disappeared or were burned. Although the forest cover has increased by about 0.4% between 2000-2010[12], the exacerbation of forest fires in the country during the last decade is still causing an accelerated process of forest degradation and loss. For instance, the disastrous forest fires in October 2007 burned more than 2,000 ha only in few days. A forest map produced by AFDC in 2007 showed that 28% of the total forest surface in Lebanon is severely threatened by a high fire risk[13].

The proper use and management of forests can play a major role in the decline of forest fires by removing and utilizing the combustible biomass that would otherwise ignite fires and burn the entire forest.

Biomass and emissions

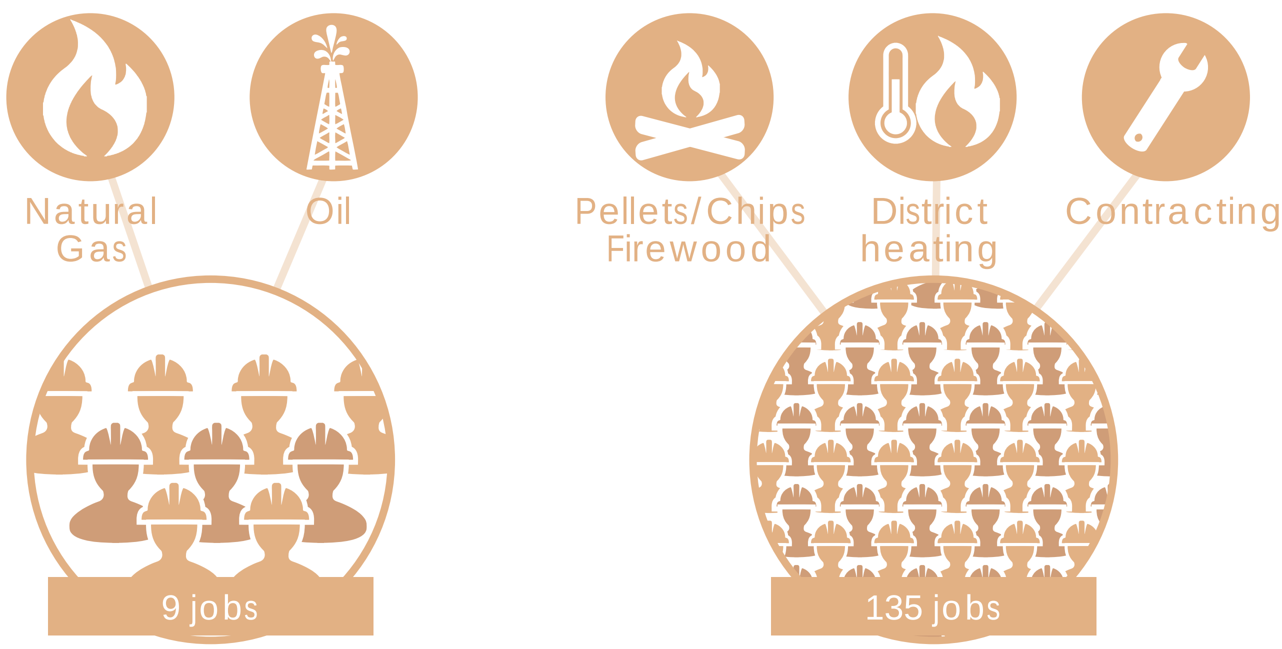
With regard to emissions, the carbon footprint of biomass is generally between 3% and 10% compared to fossil fuels such as diesel. In addition the use of wood for heat produces lower emissions of sulphur and nitrogen oxides than diesel.

Biomass and heating stoves

In the rural areas of Lebanon the stoves used for heating homes are of the traditional type. They are composed of a simple combustion chamber directly connected to the chimney and only have an outside air intake. Some stoves have been modernized with oil tanks as fuel to generate heat and are located inside the house, where one breathes the strong smell of diesel fuel. The stoves configuration, whether they burn wood or diesel fuel, does not allow the proper dissipation of heat, and most of them are underperforming at rates of up to 55%. The main advantage of the existing stoves is the low purchase price.

Economic stoves with higher yields could be designed in a simple way. However, the project in this first phase will mainly support improvements in the collection, processing and marketing of forest and agriculture biomass suitable for the existing stoves used

List of jobs created by type of energy per 10,000 people



Source: www.Biomasseverband.at

[10] *http://www.todosbiomasa.com*
[11] *FAO (1997) State of the World's Forests.*
[12] *FAO (2011) State of the World's Forests.*
[13] *AFDC (2007) State of Lebanon's Forests.*

by most of the population in the rural areas of Lebanon. In a second phase, the project will look at improvements in stove design to identify high-efficient and low-polluting models accessible or easy to manufacture in the country and within the purchasing capacity of the rural population.

Biomass and consumers

The project undertook a survey among people living in the vicinity of Kfarfakoud and Dalboun, who were visited and interviewed to gather their views on briquettes, charcoal and wood for domestic heating.

Positive comments regarding the use of briquettes and its advantages included: a) unlike diesel, briquettes do not smell bad b) briquettes do not break and c) no problems in stoves because of oil residues.

Negative comments point out that a) the briquettes are not sufficiently dry and b) sometimes the briquettes have to be put in a room or outdoors to dry under plastic until the following winter.

Biomass and competing sources of energy

Fossil fuels: At present diesel oil is well established as a source of energy. However the major economic, environmental and social benefits of biomass will gradually shift in favour of biomass and away from diesel oil when the briquettes begin to be better known through improved distribution and a competitive price. Electricity: is well distributed throughout Lebanon but is a very expensive source of heating and is subject to frequent cuts. Most localities have large diesel generators to replace the government power supply when it fails.

Summary of different fuels for thermal energy

	Diesel	Wood/ Charcoal	Briquettes
Price kWh	☹	☺	☺
Storage needs	☺	😐	😐
Forecasts of future prices	☹	☺	☺
Social impacts	☹	☺	☺

The Kfarfakoud Briquette Center

3. The Kfarfakoud Briquette Center

Old and new location

Near the village of Kfarfakoud is a small facility where briquettes are produced by mixing olive residues (pomace) and woodchips (pruning of stone pines, olive trees, vineyards, apple orchards, and oak forests). The average mixture is 60% pomace (with 50% humidity) and 40% woodchips (with less moisture). The pomace is provided by the oil presses in the area that deliver it to the facility, while the woodchips are made with material from pruning or clearing.

The old Kfarfakoud briquette factory is located at an altitude of 569 meters whereas the new location is located at an altitude of 608 meters. As shown in the following aerial photograph, the area of activity of the briquetting plant covers at least 100,000 ha. The new Kfarfakoud Briquette Center will be in a different building that is larger and better located. Production processes will be improved as well as the design of the plant, which will continue to produce briquettes from olive pomace and sawdust. It is anticipated that the improvements in the supply of raw material, pre-treatment, mixing, manufacturing, drying, storage and sale will encourage many consumers to stop using fuel oil. These briquettes will be much cheaper to use per unit of heat generated.

Equipment for the new center

- Concrete storage areas for olive pomace, sawdust and the mixture of both.
- Hoppers or silos.
- Micro-sprinkler system to humidify the mixture
- Briquette machines.
- Drying facility consisting of a stove fuelled by its own briquettes and the use of fans.
- Metal structures for drying the briquettes.
- Briquettes moving equipment including a loader and conveyor belts.
- Bobcat for moving briquettes on pallets in the storage area.


RANGER
HINO

- Weighing scale and packaging bags.
- Tractor with shovels and chippers.
- Saw mill.
- Roll-off truck carrying pallets.
- Mobile pyrolytic furnace.
- Offices, exhibition room and services.
- The new building consists of two blocks, one for production and one for storage, sale and distribution. The layout and general measurements can be seen in the Fig.1.

Making briquettes

- Products to be used are olive pomace and woodchips.
- These products are stored outdoors separately on a concrete slab. This facilitates handling and loading the materials and avoids mixing the pomace and woodchips with impurities by keeping them off the ground.
- The production plant has been designed to consist of a feed hopper that pours the mixture of olive pomace and woodchips on a conveyor belt that will distribute the mixture to two machines that mold the briquettes. During the process micro sprays are used to humidify the mixture and avoid clogging. The hopper is loaded with the olive pomace/woodchip mixture using a small loader (Bobcat) or with specific containers that open when tilting.
- As the briquettes exit the moulding machine two persons are needed to cut the briquettes (as it is not mechanized) and another two persons to place the briquettes in the specific containers that will be moved by forklift to the drying area.
- Freshly prepared briquettes have a humidity of 37% and split easily. However, after 20 to 30 days of air-drying the humidity is reduced to the required 17% before sale.
- Each container can hold 384 briquettes. The drying kiln will fit 45 containers or a total 20.7 tons / kiln. When dry the briquettes are packaged for sale. The weight at time of sale is 460.8 kg per container.
- The briquettes are stored in plastic boxes in the facilities and once they are dry are put in bags and sold in the manufacturing center and at a nearby gas station.

The two briquetting machines were designed in the (old) Kfarfakoud Center by Samer Khawand and his team at the cost of US$9,000 each. The machines are not automatic and depend on intermittent electricity that is backed by diesel-powered electric generators.

Relevant data on briquettes

- The Lower Calorific Value (LCV)[15] of the briquettes compared with other wood is as follows:

- 1 kg of briquettes provides 4.65 kWh/kg, the same heat that 1.25 kg of oak wood (oak wood consumed is about 30%-35% moisture), or 1.5 kg of olive wood (olive wood consumed is about 35% -40% moisture).

Raw materials needed to make briquettes

Year	Briquettes t/year (17% MC[14])	Briquettes Number/year	Forest Woodchips (t/year) (45% MC)	Fruit tree Woodchips (t/year) (45% MC)	Olive Pomace (t/year) (30% MC)	TOTAL raw material (30%-45% MC)
2013	1,200	1,000,000	357	238	800	1,394
2014	1,489	1,241,000	443	295	993	1,731
2015	1,848	1,540,081	513	403	1,232	2,148
2016	2,293	1,911,241	591	546	1,529	2,666
2017	2,846	2,371,849	677	734	1,898	3,309
2018	3,532	2,943,465	771	981	2,354	4,106
2019	4,383	3,652,840	869	1,303	2,923	5,095
2020	5,440	4,533,175	971	1,726	3,627	6,323
2021	6,751	5,625,670	**1,071**	2,276	4,501	7,847

[14] *Moisture content*

- Each 2 kg of briquettes has the same lower calorific value (LCV) as a liter of diesel. The retail price for 2 kg of briquettes is about US$0.35 to US$0.40 and the price of a liter of diesel is about US$1.00. Thus the briquette costs US$4.30/kWh, whereas diesel costs US$10.65/kWh for the same heat generation.

- Each briquette weighs 1.2 kg and is 10 cm in diameter and 35 cm in length.

- Each briquette takes about an hour to burn (it lasts more than oak wood).

- Bulk selling price of energy:
• 1 ton of briquettes is currently sold at US$167/ton at the factory (US$200 for 1,000 pcs.). This price is US$ 3.59/kWh.
• 1 ton of oak wood is sold for US$250. This price is US$ 5.97/kWh.
• 1 ton of olive wood is sold for 200US$. This price is US$ 5.21/kWh

- One million briquettes were produced in 2012 with one of the two existing machines, which is equivalent to 1,200 tons/year. This level of production requires six workers, four of them chipping forest and agricultural residues and the other two at the factory making briquettes. The first group worked for four winter months and the second for two months.

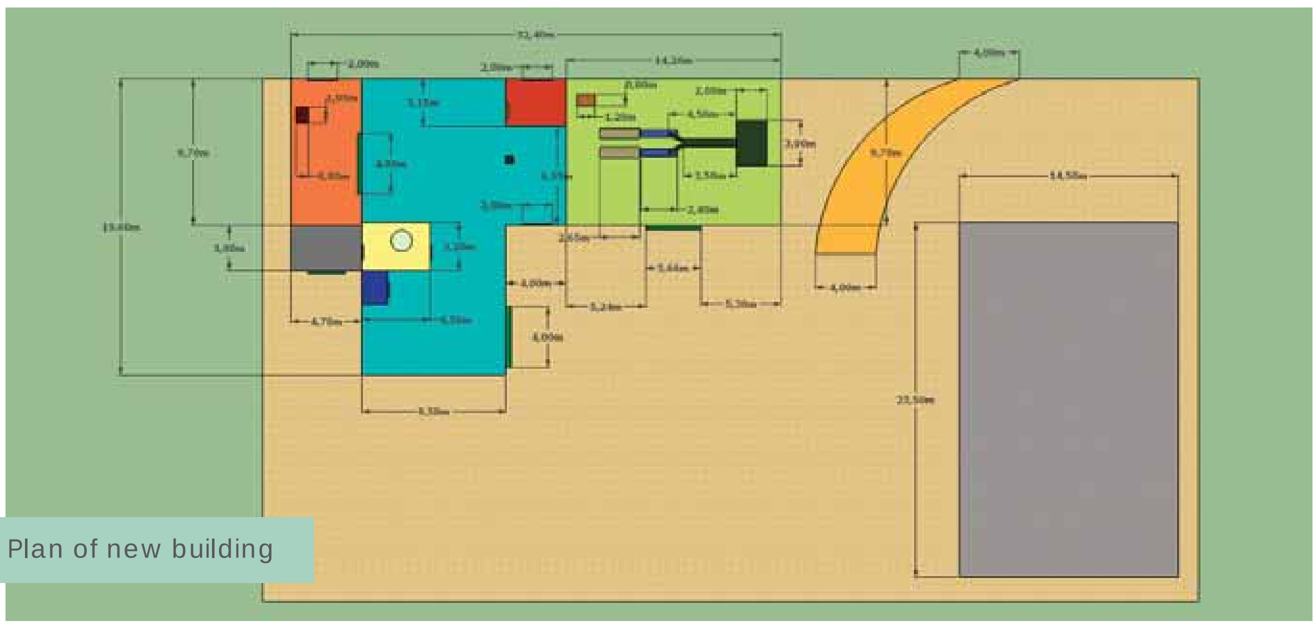
-This amount replaces a total of about 600,000 liters of diesel per year, with a total savings of:

• 600,000 liters of diesel at 1 US$/liter = 600,000 US$/year
• 1,200 tons of briquettes at US$ 167/ton briquettes = US$ 200,000 / year
• The difference is US$ 400,000 in annual savings for consumers

Cost of Manufactured Products	
Raw material cost (pomace):	67.80 US$/t
Raw material cost (transport and sawdust):	8.00 US$/t
Manpower Cost (briquetting):	12.00 US$/t
Manpower Cost (sawing):	15.00 US$/t
Management Cost:	5.69 US$/t
Machinery depreciation Cost:	1.88 US$/t
Cost factory rent:	- US$/t
Maintenance and Repair:	3.00 US$/t
Electricity, diesel, etc.: (variable):	3.10 US$/t
Electricity, diesel, etc.: (fixed):	2.08 US$/t
Packing bags:	5.20 US$/t
Pallets:	- US$/t
Web, image and campaign launch:	- US$/t
Fire extinguishers, insurance and consumables:	- US$/t
Project and project works management, etc.:	- US$/t
Financing:	14.63 US$/t
Total Cost:	**138.06 Us$/T**
Industrial Profit:	**20.72 %**
Total Sales:	**166.67 Us$/T**

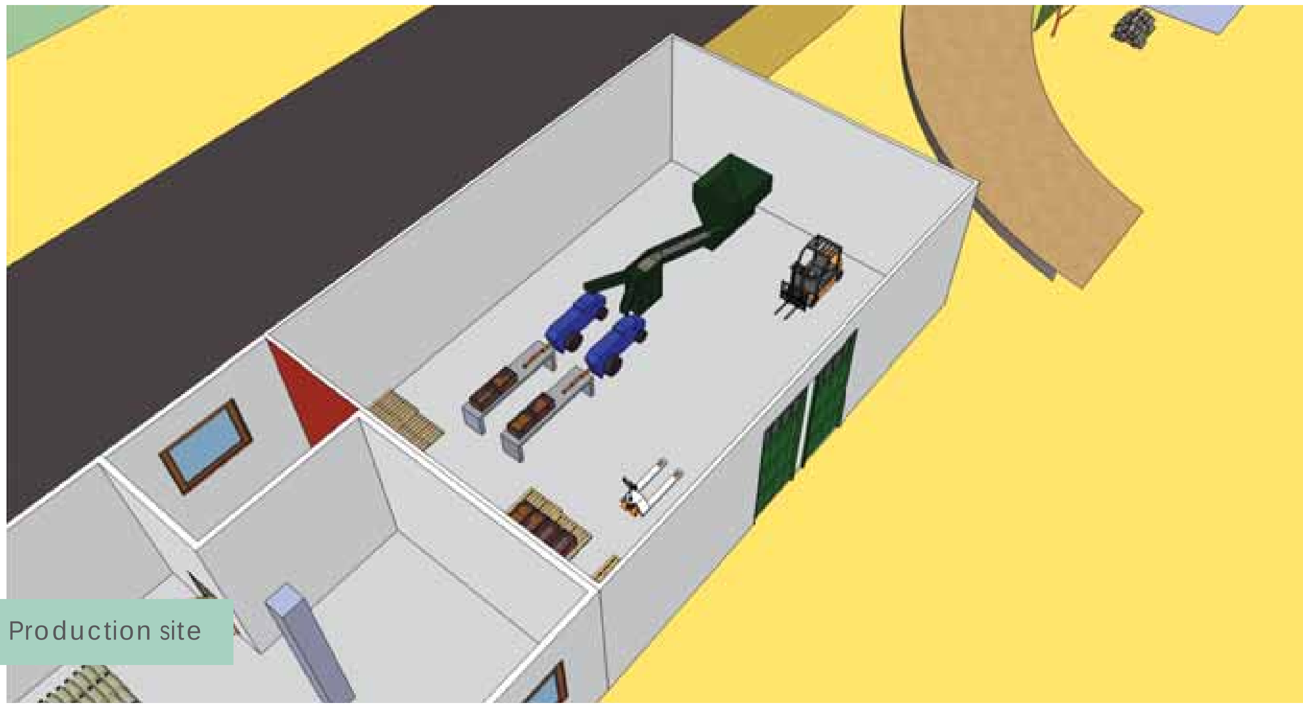
15 *The quantity known as lower calorific value (LCV) net calorific value (NCV) or lower heating value (LHV) is determined by subtracting the heat of vaporization of the water vapor from the higher heating value. LCV calculations assume that the water component of a combustion process is in vapor state at the end of combustion, as opposed to the higher heating value (HHV) (a.k.a. gross calorific value or gross CV), which assumes that all of the water in a combustion process is in a liquid state after a combustion process.LCV calculation is useful in comparing fuels where condensation of the combustion products is impractical, or heat at a temperature below 150 °C (302 °F) cannot be put to use.*

Fig.1: General view

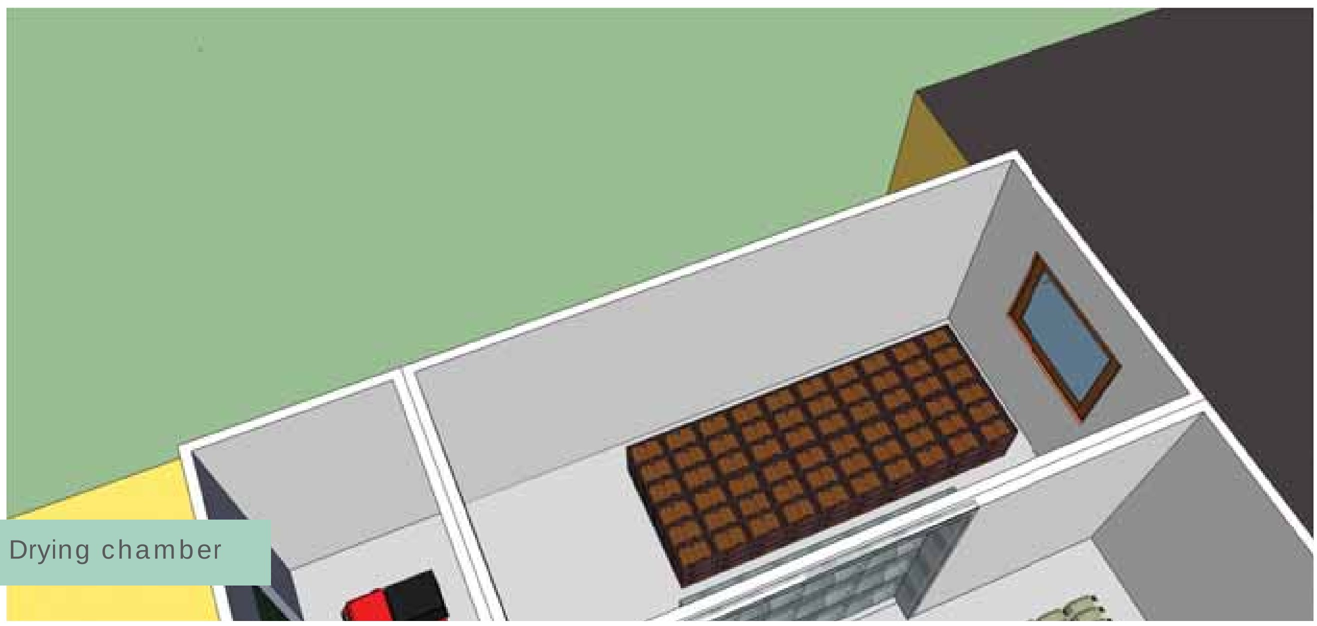


Plan of new building

Distribution of functions



Production site



Drying chamber

Distribution of functions


BOILERSMITH

Plans for the New Kfarfakoud Briquette Center

Drying chamber

The drying zone is equipped with a briquette-fired boiler. The chamber must be properly ventilated to allow the removal of moist air by fans. The drying process is thus reduced to one day – compared to the 20 days that were previously required for drying the wet briquettes. After drying, the briquettes are moved into the storage and distribution area (Fig. 1) where they are bagged and placed on pallets for quick and easy loading.

Drying kiln[16] and boiler

Drying fans are used to force air to flow through the metallic structures containing the briquettes. If the dryer is empty leave the door ajar to prevent a high temperature.

It is advisable to install fans that can reverse their rotation to allow air to circulate from both sides thereby promoting the homogeneity of the moisture content of the briquettes in the drying process.

The boilers used in the drying process must have automatic loading fuel and the boiler furnace must be of steel to prevent corrosion problems in the future. The boiler should have a power of at least 260 KW, or two parallel boilers 180 KW each.

The heat inside the dryer can be provided directly from the boiler hot air or hot water through wind turbines arranged in ceiling and walls thus saving up to 30% on fuel.

The boiler will produce hot air with low moisture content that not only heats the drying chamber, but can also be used to heat the offices, amenities and storage and distribution area.

[16] *A kiln is a thermally insulated chamber, a type of oven, that produces temperatures sufficient to complete some process, such as hardening, drying, or chemical changes.*

The Dalboun Oak Forest

4. The Dalboun Oak Forest

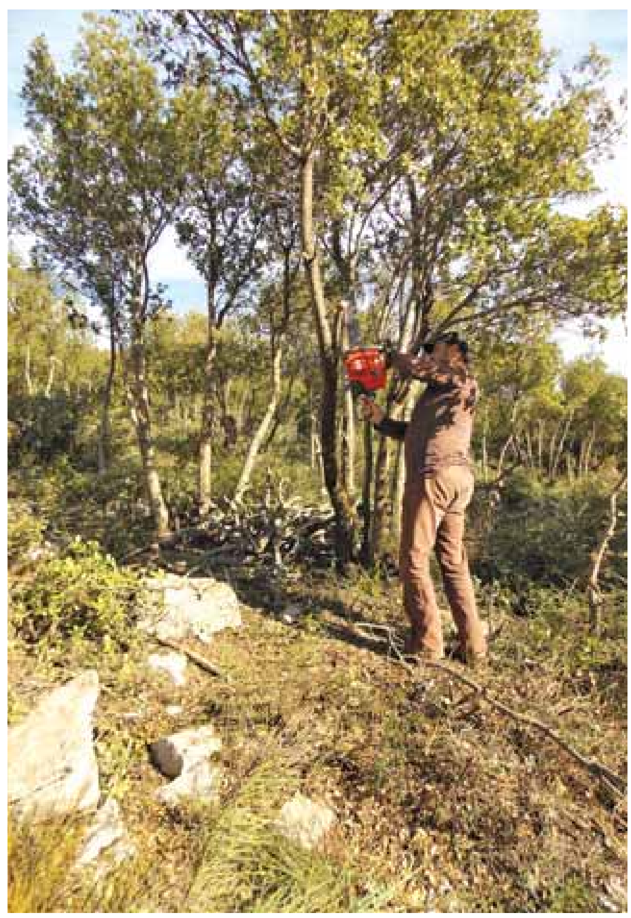
The forest

Dalboun is a typical coppice forest of the evergreen oak *Quercus calliprinos,* where thinning and pruning have occurred in the past without a long-term plan for the use of the wood for generation of thermal energy. Shepherds with sheep and goats use this area for grazing and browsing, and some firewood and twigs are given to nearby municipalities to distribute among their residents. Until now the unused twigs and small branches were put through a chipper attached to a tractor PTO or were buried in a large ditch dug in the area using a mechanical shovel, as a precaution against forest fires.

The testing of the thinning of coppice sprouts was conducted in Dalboun forest with the purpose of obtaining quality wood, residues, and possibly charcoal logs. These tests were conducted to normalize the exploitation of the forest and manage it by taking full advantage of the firewood and debris that may be transformed into charcoal or sawdust for the briquettes mix. The team in charge of the demonstration is made up of a chainsaw operator and two workers who remove and separate the wood.

This forest management system will provide sustainability to the oak forest in economic, social and environmental terms. It will also contribute to climate change adaptation and mitigation: (i) appropriate thinning helps reduce competition for the scarce water resources among individual trees and coppice sprouts, limiting dieback events, forest pests and fire risk; (ii) the thinned areas of the forest show a more vigorous development of the remained sprouts than the un-thinned areas, with a healthier tree growth and higher capacity for carbon sequestration.
The Dalboun Oak coppice forest has an area of approximately 200 hectares and sits at an altitude of 1,250 meters with the following coordinates: X: 33 41´20,12´´ N and Y: 35 32´35,67´´ E. Its traditional use for firewood harvesting has undergone a process of abandonment, causing shoot growth stagnation with competition for the scarce water resources, that resulted in the accumulation of dry biomass and the increase of pests and fire risk. In the area nearby Dalboun there are about 1,000 ha of similar coppice forest from which biomass could also be used.

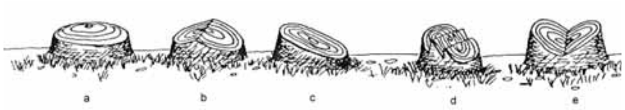
The project has undertaken some tests involving the thinning of coppice sprouts, which produced excellent results clearing the forest structure and thereby encouraging the growth of more vigorous and healthier remaining shoots. Once Dalboun forest is properly managed it can supply the surrounding villages with firewood and charcoal in a sustainable manner.



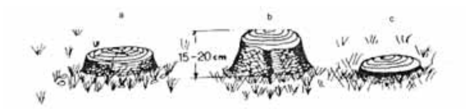
For the sustainable management of this type of coppice forest, the size of the annual thinned area will need to be determined based on the overall size of the forest surface and the ability of the trees to sprout back vigorously. In the majority of species this is achieved in 6 to 10 years. The maximum age at which sprout capability is maintained in *Q. calliprinos* forests it is about 120 years. The total number of recurrent thinning operations before vegetative decay varies with species. In the case of oak forests it is about 10 cuts.

Shape of the cut

Regarding the shape of the cut the operator must leave the face of the stump completely smooth, inclined or convex.



Correct ways to cut coppice: a), b) and c). Incorrect ways: d) and e). (Capelli, 1991[17])



a) High cut above the ground, suitable to any type of sprouting, b) Higher cut for root sprouting species c) Ground cutting). (Capelli, 1991 [18])

The time to cut should be within the period of vegetative halt, so as to encourage sprouting in the following spring, but avoiding the potential damage of heavy frost. In areas with cold winters and wet springs, is preferable to cut at the beginning of spring, while in areas with mild winters and dry springs late fall is the best time.

Chainsaws

It is advisable to use professional chainsaws. It is also important that the operator should be properly protected. Below some examples are attached.

201: bar length 30-35 cm
Light petrol chainsaw for forestry jobs, 1.8 kW power output. If chosen we recommend a 30 cm bar.

MS 261: bar length 40-45 cm
This is a high performance chain saw for forestry jobs with 2.8 kW power output. It is one of the best selling models in the world with parts or spares available when needed. This is the model we recommend with a 40 cm bar.

Protective equipment

Cut resistant foot wear
EN ISO 17249, cut resistance class 1(= 20 m/s). Steel midsole S3 (BS EN ISO 20345).

Face and ear protector
Face protection with nylon mesh, double headband and ear defenders. EN 352, EN 1731, SNR 30 (H: 34; M: 27; L: 18) (up to 110 dB(A))

Chain saw gloves with cut protection
5-Finger leather gloves, EN 381-7, Protection Class 1 (=ˆ 20 m/s), with cut-resistant inlay in the back of both gloves.

[17] *Cappelli M (1991). Selvi coltura generale. Edagricole, Bologna, pp. 489.*
[18] *Ibid.*

Chain saw trousers with cut protection

Other forest types

In addition to the Dalboun evergreen oak coppice forest type, there are various forest communities that can be used for wood harvesting: deciduous oak forests characterized by *Quercus infectoria*, pine forests characterized by *Pinus brutia* and *Pinus pinea*, and mixed oaks and pine forests.

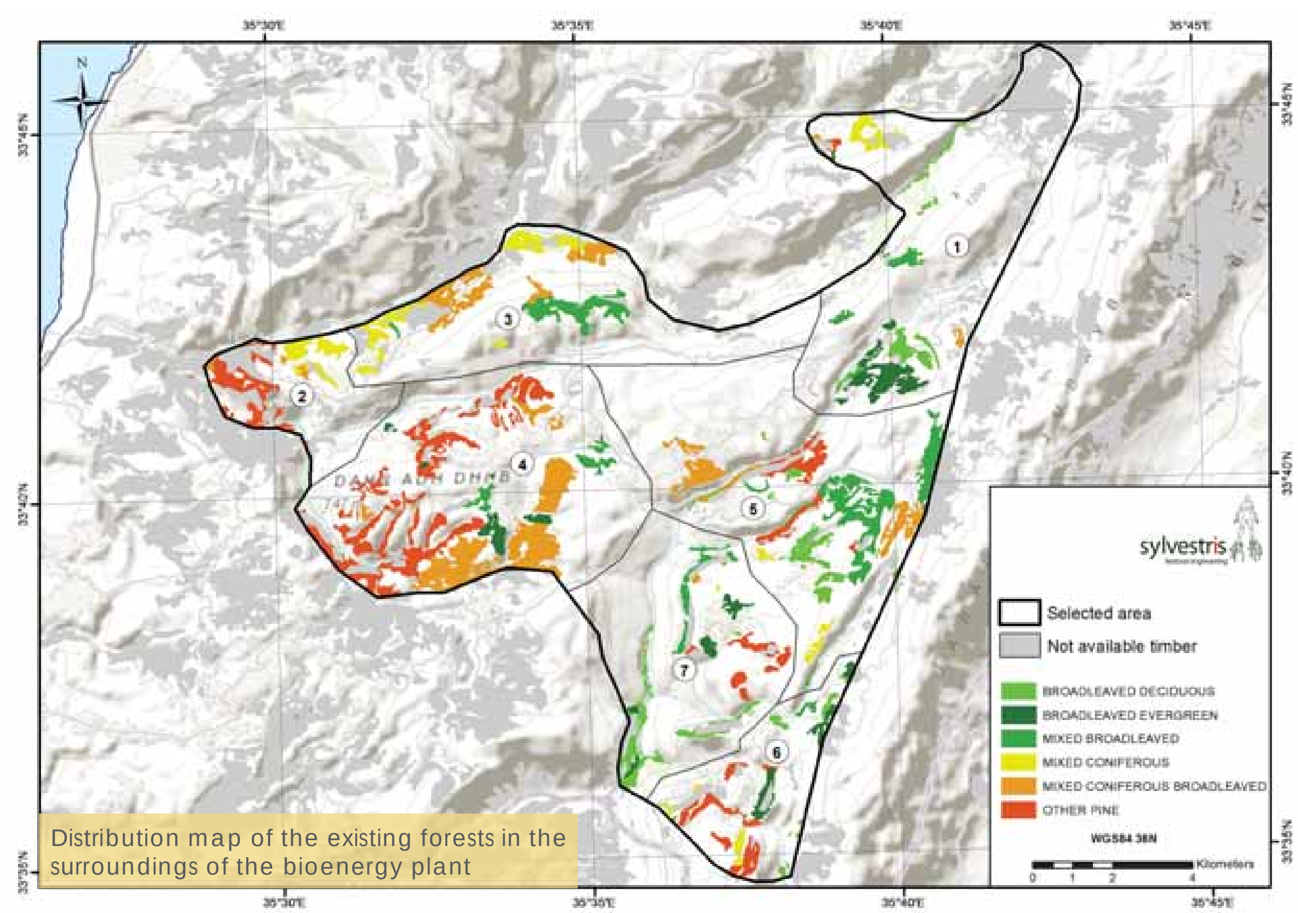
Although it is illegal to cut down conifer trees, the law allows the removal of the branches from the clearing of the canopy. The thinning of deciduous forests and pruning of fruit tree orchards is also allowed. It is also possible to get permissions for the thinning of pine forests under special conditions: over-matured stands, too dense stands, and forest sites with high fire risk.

A survey took place in November 2013, to evaluate the amount of wood that the mountain forests in the area around Kfarfakoud can supply to the new briquette plant. The territory of the survey was divided into seven areas with less than 30% slope, while wooded areas with a slope greater than 30% were discarded. Studies were conducted on the forest species distribution, size, crown closure (CC) and exploitation strategy.

Types of available wood

Coppice broadleaf stands: forests formed by *Quercus calliprinos*, *Quercus infectoria*, or a mixture of both, with different coppice stands that have an average diameter between 6 and 7 cm each, a height between 3 and 5 meters and a crown closure between 40% and 90%. The cutting period is 15 years. Only the thin wood will be taken into account for woodchips (twigs, branches, etc.). Additionally, it will be possible to collect 2,875 tons/year of thick wood that will be mainly used in stoves and will therefore not be used to manufacture briquettes.

Pine forests: *Pinus brutia* stands are often found colonizing old abandoned terraces and in steep hillsides. The pine trees have an average diameter of 15-25 cm, a height between



Distribution map of the existing forests in the surroundings of the bioenergy plant

4 and 10 meters, and the crown closure is between 45% and 90%. No cutting of pines is allowed under the current legislation; only the pruning of tree crown is allowed.

Mixed broadleaf and pine forests: Mixed stands are often found on steep slopes and abandoned terraces.

The supply of thin forest wood (twigs, branches, etc.) is limited to the surrounding area of the bio-energy plant, where wood collection and transportation to the plant will be cost-effective. Available wood does not exceed 1,000 tons/year, with an initial moisture content of 45%. As a result of this limitation it would be necessary to increase the amount of agricultural wood – pruning of fruit tree orchards – to be acquired each year, by reaching agreements with farmers for organizing the collection of raw materials - such as gathering them on the outskirts of towns and in controlled areas. Organizing the collection of agricultural wood in each town in stockpile sites will be paramount in making the woodchips profitable and to facilitate the transport of mobile machinery to each stockpile point.

According to the information gathered, the

availability of olive pomace (olive pressing residue) that is produced every year in the area, as well as the available wood resulting from the fruit tree pruning, are not a limiting factor. A greater quantity of both residues is produced each year than what the plant could absorb:

- There are 1,650 ha of olive orchards and 600 ha of other types of fruit tree orchards in the area surrounding the bio-energy plant. Considering an average amount of 2 tons of wood residues per hectare from the pruning operations, it is estimated an available amount of 4,500 t/year for the production of woodchips.
- There are 20 olive oil pressing centers in the area surrounding the bio-energy plant. 10 pressing centers are large with the capacity to produce 600 t/year of olive pomace each; the other 10 pressing centers are small to medium with an average capacity of 40 t/year up to 200 t/year. Therefore, we can estimate an available amount between 6,400 t and 8,000 t of olive pomace every year.

The use of thin forest wood reduces the presence of combustible material in the forests thereby reducing the risk of forest fires. Moreover, the use of fruit-tree pruning wood for briquettes or charcoal prevents the widespread custom of farmers to burn the trimmings, which is the main cause responsible of the majority of forest fires in Lebanon.

If the supply of both forest and agricultural wood is occasionally low, an increase in the amount of olive pomace for the manufacturing of briquettes is possible. A small olive oil mill was visited which produces about 40 tons of olive pomace per year. The briquettes made of 100% olive pomace worked well in local residents' stoves.

Re-sprouting control

To prevent the excessive re-sprouting of the thinned oak stands, and hence a higher chance of forest fires, it is recommended to graze the area with herds of goats during the years following the cutting operations.

The reported presence of goat herds in the Dalboun Oak Forest is the following:

- Two shepherds: one with 300 goats and another with 200 goats graze in the spring.
- In summer these are joined by a third shepherd with 500 goats.
- In principle the three shepherds overlap for a time period, so the livestock density at the peak is 1,000 goats over 200 ha.

Charcoal

5. Charcoal

Charcoal has a number of uses: it can be burned directly in traditional stoves, as mix for briquettes, or as fuel in the traditional water pipe of the region (nargila/ sheesha/ hubble-bubble/hookah). Making charcoal is a rural activity that is gradually being lost and could be of great value for rural employment if revived.

Charcoal has a higher calorific value(about 7,500 kcal/kg almost double the briquettes that are currently being manufactured) and can increase the quality of the briquettes. However this process should be studied and tested in the production plant before commercial production is started.

Manual production of charcoal

The following steps outline the production of lava stone charcoal from small branches:

1. Pile all cuttings and branches into sheaves.
2. Once the area has been cleared and the sheaves are in place, start the fire on the first sheaf. More sheaves are then piled around while taking care not to cause a forest fire.
3. Always have enough water containers nearby to put out the fire. This work should never be done on a windy day.
4. Before branches become dust put out the fire with water and remove.
5. Keep cooling the lava stones using a shovel instead of water to maintain a good charcoal quality.
6. By turning over the cooled charcoal the air will help to separate the dust from the charcoal.
7. Once the process of making small lava stone charcoal is over, the product is placed in bags.
8. The bags are then placed apart in case one burns and ignites the other bags nearby.

In Lebanon charcoal is not usually used in traditional stoves but as fuel for barbecues or for use in hookahs.

The smaller pieces of charcoal that come from charcoal making can be used for briquetting.

Charcoal can also be obtained by crushing large pieces of charcoal if it proves to be more profitable to consume it in the form of briquettes.

Data collected in the field have yielded the following information:

- Each ton of removed branches yields about 250 kg of charcoal.
- A coalman charges US$100 / day.
- In seven days the coalman can work 3 or 4 tons of branches which yields about 0.75 to 1 ton of charcoal at a cost of US$ 700.
- Charcoal is sold in bulk at US$ 2 / kg and retail in stores at US$ 3 / kg.

The data above refer to charcoal made from oak wood (*Quercus*).

Charcoal production with oven

The pyrolytic carbonization furnace Piroeco HCPP-Rural 9 is a modular oven that requires no power connection for operation and is easily transportable by truck to the place where the wood is cut. Thus you can have this oven in the briquetting plant, and charcoal can be made in the same factory, or it can be transported to the mountain to make charcoal thereby saving biomass transport costs. The choice of one option over the other depends on cost effectiveness.

The wood should go into the oven with moisture content below 25%. In case the furnace is operated in the biomass plant the possibility of drying the wood prior to putting it in the kiln should be considered. Drier biomass in the kiln results in higher quality charcoal.

The furnace in the photo on the right consists of a combustion chamber and a pyrolysis chamber. The combustion chamber burns waste wood (or other biomass that is not going to make charcoal) to generate the heat required for the pyrolysis of wood. The pyrolysis chamber consists of a chimney extractor for gases, a flue gas cleaning system and a thermometer to read chamber temperatures. It is possible to adapt a recirculation system for combustion gases in the combustion chamber to generate the heat required for pyrolysis, which is a greener alternative to burning wood for the same purpose.

The oven is 2 meters high, 2.20 meters wide and 4.40 meters long, weighs 3.2 tons and the capacity of the pyrolysis chamber is 9 m³. Carbonization cycle lasts between 36 and 48 hours, each cycle producing about one ton of charcoal. On average, it can be said that the production rate is one ton every two days, with a yield of 80% superior to that of traditional piles of charcoal. Furnace cooling is slow, since it must be cooled with the furnace filled. For control, loading and unloading, two or three workers are sufficient.

Marketing Plan

6. Marketing Plan

The Thermal Biomass project seeks to encourage private (family) users of heating stoves to use briquettes/charcoal instead of diesel fuel. The short-term target is private consumers, especially in homes that want to change from fossil fuels to more affordable local biomass for burning in their traditional stoves.

The research carried out by the MM project shows that the area within a radius of 25/50 km around the Kfarfakoud Briquette Center and Dalboun Oak Forest is where the collection of biomass becomes competitive with other energy alternatives such as fossil fuels.

Finally the presence of retail outlets like gas stations, stores that sell heaters, supermarkets, etc., will be key in the distribution of briquettes. Equally important is the need for improvements in stoves to raise their performance from 55% to 75-80 %.

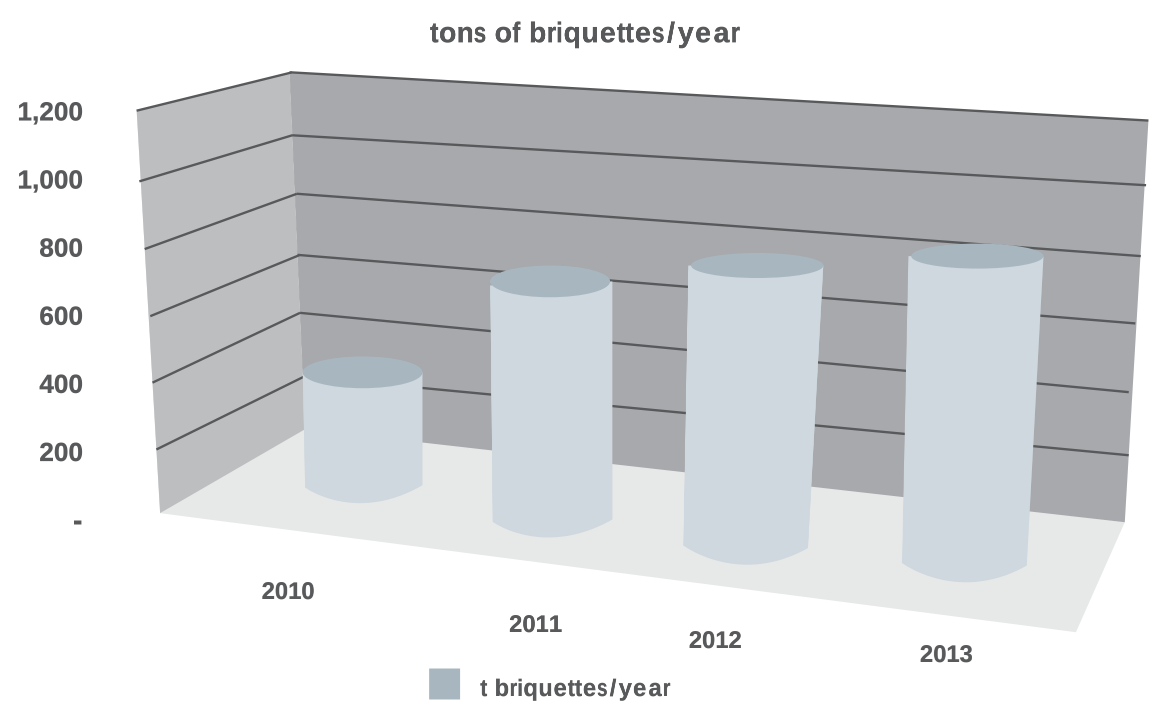
The sale of biomass to date

The Kfarfakoud Briquette Center was established three years ago and sales have been increasing over the last few seasons without any distribution campaign. This means that there is already a base of customers who rely on the product because of its competitive price.

Sales in 2012 amounted to US$200,000 (US$166.67/ton of briquettes). The thick wood collected in Dalboun oak forest was not sold but given away to families in the vicinity. So far, the branches and twigs from Dalboun were buried and not exploited for consumption.

Consumption by altitudes

The difference in altitude clearly influences



consumption per house. At higher altitudes there is higher consumption of briquettes because of the longer winters and lower temperatures.

According to data collected in the field, median consumption is as follows:

- 500-700 meters: 1000/1500 briquettes/year (1.2 - 1.8 tons/year).

- 800-1000 meters: 1500/2000 briquettes/year (1.8 to 2.4 tons/year).

- 1100-1400 meters: 2500/3000 briquettes/year (3.0 to 3.6 tons/year).

Marketing strategy

The project will aim to convert customers who currently use diesel oil to heat their homes and businesses into users of briquettes, firewood or charcoal for energy. Preference should be given to homes and businesses where the general public can witness and try out the new biomass heating system.

In addition to briquettes there are two other biomass products that this project is keen to commercialize:

1. Firewood is one of the simplest forms of biomass used for heating and cooking. It is extracted from the thinning and pruning of oak trees such as *Quercus calliprinos*. Its advantages are similar to those provided by briquettes, however it is more expensive and contains a higher level of moisture.
2. Charcoal is a solid fuel, fragile and porous with a high carbon content (around 80%), and with a much higher calorific value than wood. It is important to note that carbon monoxide (CO), a product of coal combustion, is highly toxic and poisonous if kept indoors, hence the importance of ventilating the interior of the house when burning coal and removing it when the household goes to sleep.

Enhancing the value chain

The following shows in detail the structure of the value chain, and the definition and distribution of the production processes:

1. Promotion: the work of promotion and publicizing of biomass (briquettes) and its advantages will begin by designing leaflets, press releases, TV, etc. All this will be reinforced with a specific website and the design of a corporate image.
2. Human resources Plan: before any production can begin the staff needs to be selected and trained.
3. Partnerships with Outlets: it is vital to establish alliances before large-scale production begins. This includes: financial agreements, volume discounts, supply schedules, logistics, storage facilities, knowledge of partners about the product and its features, pricing, and payment terms.
4. Material Selection: partnerships with suppliers are as important as sales. A regular supply of raw materials, agreed prices, and timely and efficient delivery will all ensure the viability of the project. It is important to have several suppliers for each of the different basic products.
5. Transport to Kfarfakoud: the transport of olive pomace and woodchips by local carriers or suppliers to the factory should be based on an agreed schedule.
6. Briquette Production: Once the machinery is ready and work plans developed, production will depend on the quantities the market can absorb. The drying time for the final product should also be taken into account.
7. Briquette Sale: customers can buy at the factory at a lower price or at other points of sale.
8. Briquette Transport: logistics are important to prevent lack of product at the outlets.
9. Turnover and after sales service: the technician hired for managing the Kfarfakoud production site will be in charge of billing follow up and aftersales service.

Briquette costs and sale prices

Briquette prices: The price of briquettes will depend on whether they are purchased in the production site or in outlets. In 2012 the briquettes were sold for US$166.67/ton. For 2013 it is estimated that the price could reach US$171.67/ton at the production center and US$182.19/ton at point of sale.

Firewood prices:The market price of oak wood is about US$270/ton for sale in bulk and packaged and marketed in stores could eventually be sold for US$300/ton at point of sale. The price of bulk olive wood is about US$200/ton, being able to quote on retail and packaging over US$230/ton.

Charcoal prices: At the moment it is sold in bulk at US$200/ton and in retail stores bags at US$300/ton.

Costs and Sales In 2013	
Raw material cost (pomace):	69.83 US$/t
Raw material cost (transport and sawdust):	8.24 US$/t
Manpower Cost (briquetting):	8.00 US$/t
Manpower Cost (sawing):	10.00 US$/t
Management Cost:	2.40 US$/t
Machinery depreciation Cost:	7.00 US$/t
Cost factory rent:	1.78 US$/t
Maintenance and Repair:	3.00 US$/t
Electricity, diesel, etc. (variable):	9.31 US$/t
Electricity, diesel, etc. (fixed):	0.74 US$/t
Packing bags:	5.20 US$/t
Pallets:	4.21 US$/t
Web, image and campaign launch:	0.09 US$/t
Fire extinguishers, insurance and consumables:	0.89 US$/t
Project and project works management, etc.:	0.51 US$/t
Financing:	17.47 US$/t
Total Cost:	**149.99 US$/t**
Industrial Profit:	**19.71 %**
Total Sales:	**179.56 US$/t**

Packaging

The function of packaging is to protect the contents, facilitate handling, state composition, list ingredients, and fulfil any other legal requirement. Packaging can also help sell merchandise through graphic and structural design.

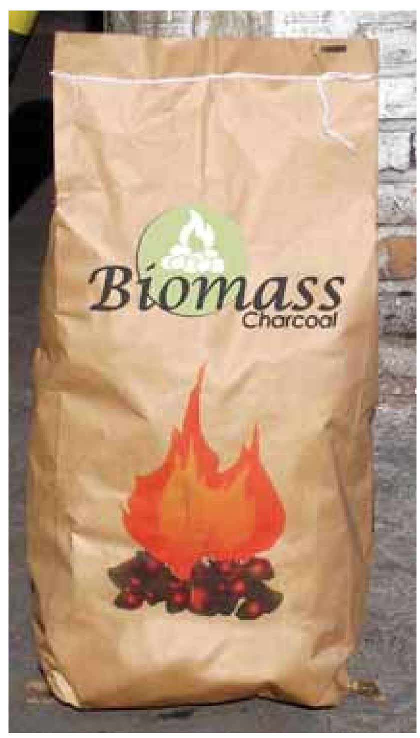
To date briquettes, firewood and charcoal have been packaged in plastic bags without any logo or trademark. A brand name and attractive design should be developed to promote sales.

The packaging used is considered correct as long as it can be closed completely to prevent leakage and contamination. It is preferable to close the bags with a bag sewing machine.

For a more urban market, briquettes, firewood and charcoal can be sold in small or medium sized boxes. In the bag or box can be printed information relating to CO2 emissions saved compared to fossil fuels and that the briquettes come from the Shouf Biosphere Reserve.

Distribution strategy

In order to achieve greater energy efficiency in the transport of biomass, the retail outlets that sell briquettes should be located as close as possible to the factory that produces them, thereby decreasing CO2 emissions and transport costs.



source: http://tidagrolimited.com/photo_gallery.html

It is advisable to have a truck with tail lift and trans pallet for moving the bags, so as to facilitate the loading and unloading. Packaged firewood and charcoal bags can be transported and marketed in the same trucks as the briquettes to points of sale.

It is highly recommended to set up a selling point for the briquettes in the high zone of the area. A local distributor in this area should be sought.

Promotion and communication strategy

Initial actions include:

1. Creation of a specific website, regularly updated and featuring the products, their prices, benefits, savings, etc.
2. Design and implementation of a corporate image for the Kfarfakoud Biomass Center.
3. Packaging design with the corporate image of the Kfarfakoud Biomass Center.

Stock Policy

Olive pomace and woodchips, the main ingredients in the production of briquettes, need to be purchased ahead of time.
The payment for such raw materials is not immediate - neither is that of the briquettes sold wholesale because they are not charged until they have been sold. It will be important to know the delay between raw material purchase and income from sales.

Platform lift

Trans pallet

Truck with platform lift

Management

The bioenergy plant belongs to ACS, and is hosted in a building owned by Mr. Walid Joumblat, the President of ACS. Currently, the plant employs 4 staff, although 8 additional workers should be employed once the plant becomes fully operational. The plant staff is composed of:

Manager (part time)in charge of the overall management. The manager takes care of the orders, liaises with the suppliers of raw material, raises awareness about the importance of the biomass use, etc.

Foreman: coordinates the production of briquettes and packaging, the transport of raw materials, etc.

Two workers, one of whom is a woman, to produce the briquettes. During the summer more daily workers are hired, including women for packaging.

Salesman to distribute the briquette to the consumers, the points of sales, etc.

Start-up costs

The total start-up costs are: (i) 25,000 € for the rehabilitation of the building; (ii) approx. 290,000 € for the equipment, including the plant machinery, the wood chipper, and the pickup, Bobcat, two briquette machines, generator, iron stands, etc.

Income distribution

The income from the production and marketing of the briquettes is used to cover the salaries of the employees of the facility, to pay for the start-up, maintenance and operational costs, to enlarge the plant operations, to improve the corporate image and packaging, and to support conservation efforts of SBR.