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Introduction to Bioenergy

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Outline

- Summary of CEDRO's actions in Bioenergy
- Introduction to the biomass technology: from fuel sourcing to thermal use
- State of the technology
- Potential raw material in Lebanon

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Summary of CEDRO's actions in Bioenergy

- The National Bioenergy Strategy for Lebanon (2012)
- Refugee Host Communities – Stoves (2015)
- Land Border Regiment 2 - Biomass Stoves (2015)
- Forest Inventory and Management Plans of Bkessine and Andket Forests in Lebanon (2016)
- Lebanon's National Blueprint for a Sustainable Forest Biomass (2016)
- Biomass briquetting process (2016)

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Summary of CEDRO's actions in Bioenergy

- Fruitful Pine Forest Management Plan for the Municipality of Bkessine (2016)
- Wild Pine Forest Management Plan for the Municipality of Andket (2016)
- Bkassine Briquetting Plant (2017)
- Aandket Briquetting Plant (2017)
- Lebanon Host Communities Support Program (LHSP) (2017)
- Sustainable Energy Strategy for the Lebanese Army (2017)

Introduction to the biomass technology: from fuel sourcing to thermal use

Ranking of bioenergy streams in Lebanon (The National Bioenergy Strategy for Lebanon)

- 1.Residues from forestry fellings
- 2.Residues from fruit and olive trees
- 3.Residues from cereals
- 4.Energy crops on currently unused land
- 5.Olive cake by-products
- 6.Waste wood
- 7.Municipal sewage sludge
- 8.Animal fat and slaughterhouse residues
- 9.Yellow grease
- 10.Landfill gas recovery (specifically Naameh landfill)

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Introduction to the biomass technology: from fuel sourcing to thermal use

- What is biomass? The European Technical Specification CEN/TS 14588 defines “biomass” as “any biological origin material excluding those that have been embodied in geological formations undergoing a process of mineralization.”

- **Solid biofuels:** Products derived from solid biomass that can be used in direct energy conversion processes, obtained from biomass by generally physical transformations, such as chipping, grinding or drying, as well as densification in the case of briquettes and pellets.

- Through five basic processes: combustion, anaerobic digestion, fermentation, gasification and pyrolysis, biomass can be converted into heat or electricity

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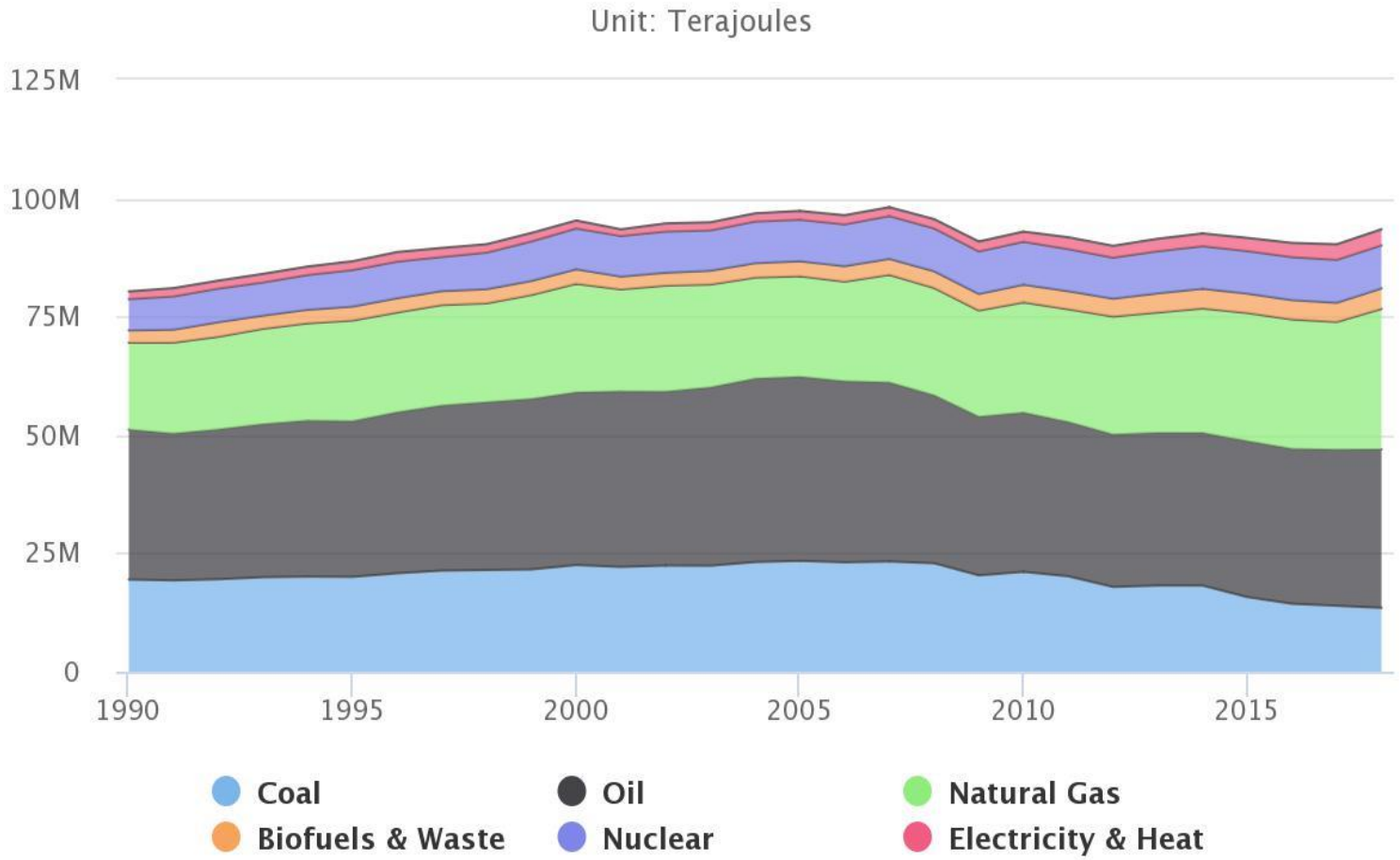
Introduction to the biomass technology: from fuel sourcing to thermal use

World Total Energy Supply by Fuel (*Source: United Nations Statistics Division*)



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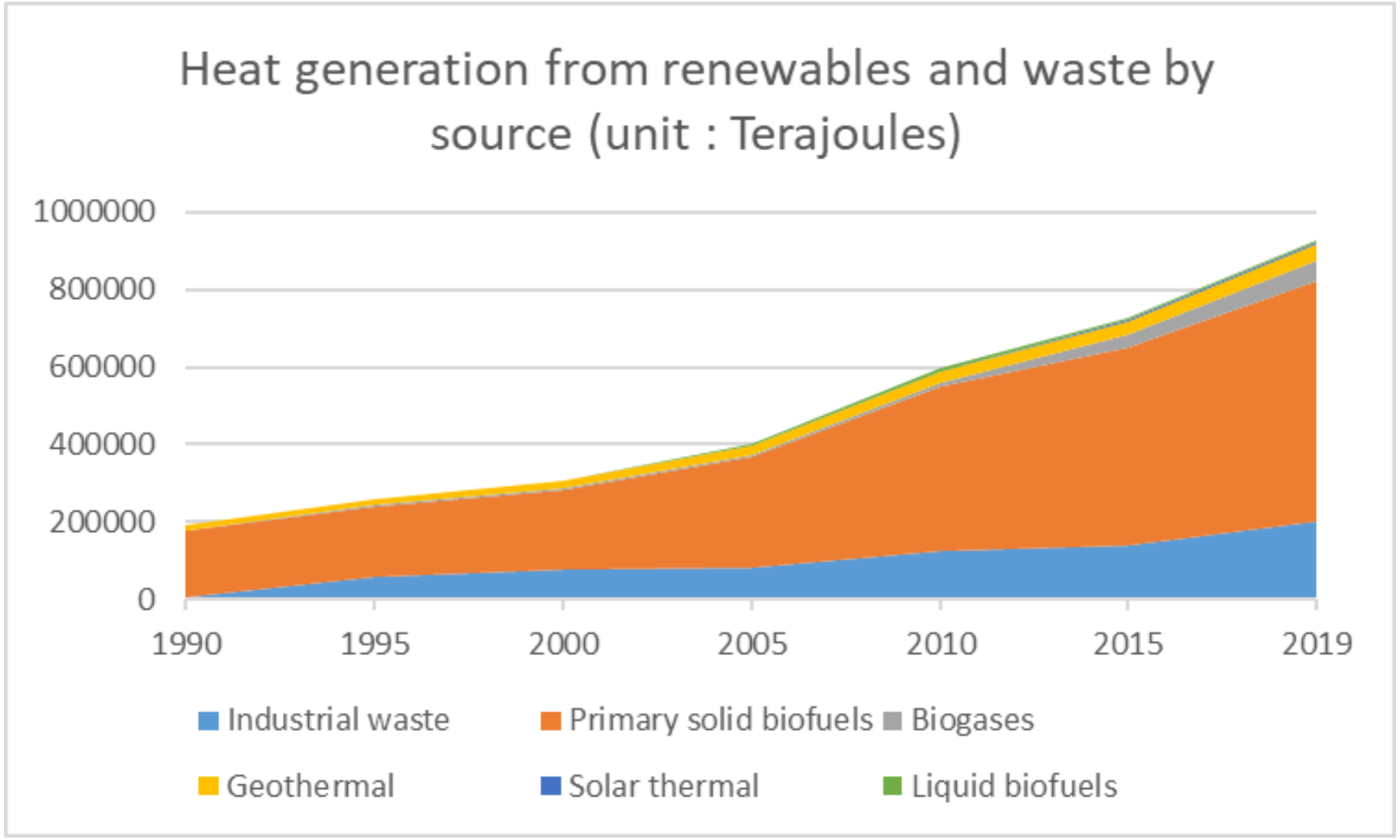
Introduction to the biomass technology: from fuel sourcing to thermal use



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Introduction to the biomass technology: from fuel sourcing to thermal use

BIOMASS RESSOURCE

- **Firewood**
- **Charcoal**
- **Chip**
- **Briquette and pellet**
- **Almond shells, hazelnut, pine nuts, olive pits**
- **Other solid biofuels**

Introduction to the biomass technology: from fuel sourcing to thermal use

- BIOMASS RESSOURCE

	Woody Biomass	Herbaceous Biomass	Biomass from Fruits and Seeds	Other (Including Mixtures)
	Wood fuels	Agro-fuels		
Primary (Energy crops)	• Energy forest trees • Energy plantation trees	• Energy grass • Energy whole cereal	• Energy grain	
Secondary (Byproducts)	• Thinning byproducts • Logging byproducts	Crop production byproducts		• Animal byproducts • Horticultural byproducts • Landscape management byproducts
		• Straw	• Stones, shells, husks	
	• Wood processing industry byproducts • Black liquor	• Fiber crop processing byproducts	• Food processing industry byproducts	• Bio-sludge • Slaughter byproducts
Tertiary (End-use materials)	• Used wood	• Used fiber products	• Used products of fruits and seeds	

Source: COWI.

Introduction to the biomass technology: from fuel sourcing to thermal use

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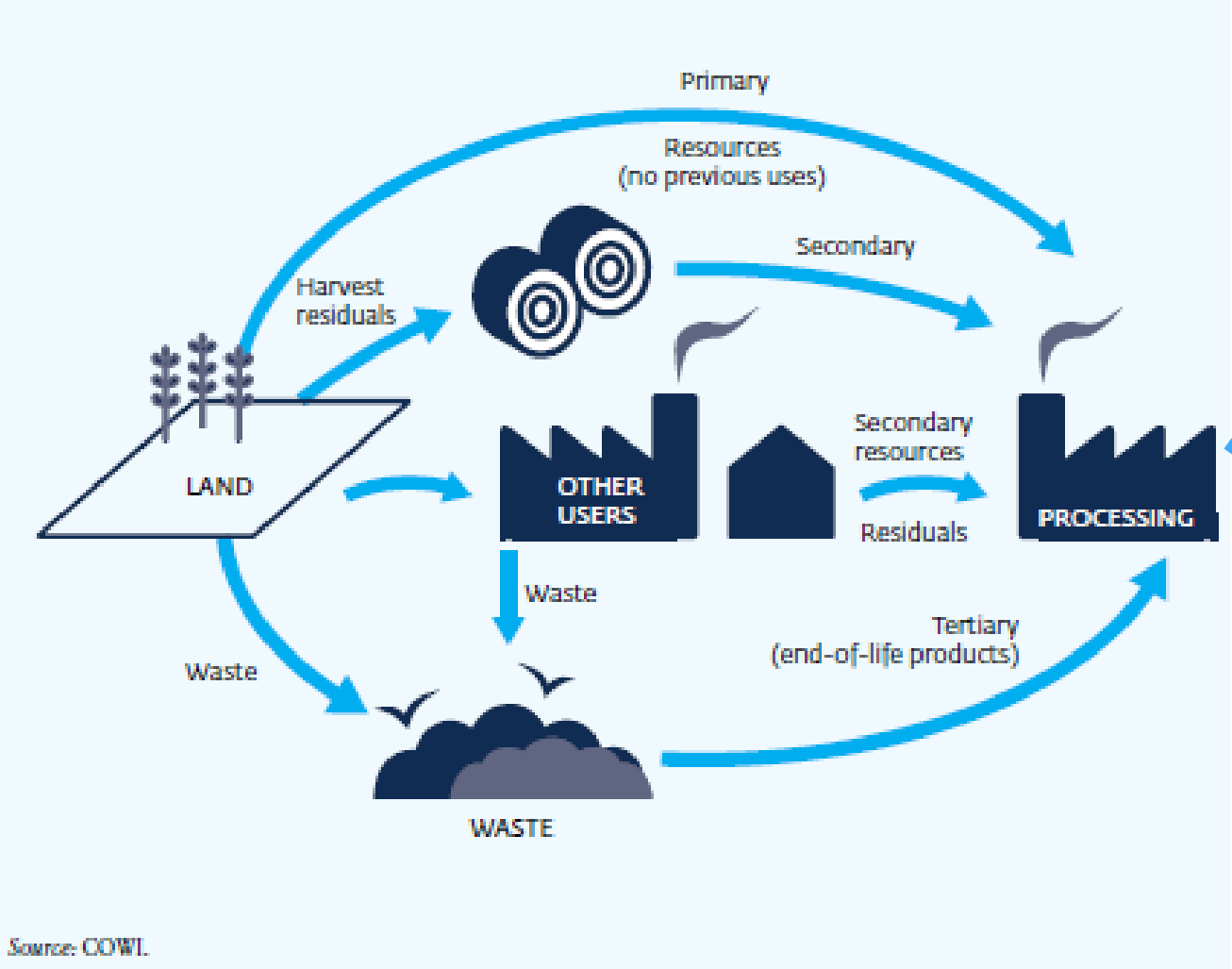
BIOMASS RESSOURCES AND SUPPLY CHAINS



Source: COWI.

Thermal generation

Stove

Boiler

Electricity generation

Power plant

BIOMASS THERMAL USE PROS and CONS

The use of thermal generation with biomass has undoubted advantages for isolated dwellings, residential buildings and any type of non-residential building, both public and private

There are many reasons why modern biomass heating and domestic hot water systems should be used :

- Installations supplied with biomass in its different forms (pellets, wood chips, crushed olive pits, etc.) are environmentally friendly
- Lower price compared to other fuels, greater stability, independent on external fluctuations, although the initial investment cost of the equipment is normally higher than that of equipment using conventional fuels (but gap reducing progressively).
- Operation and maintenance is simple, can include automatic systems with electronic control.
- Cleaning of the equipment can be fully automatic and the removal of ashes is a rare task.
- Biomass boilers resistant to wear and tear, have a long service life and, most importantly, have a good energy efficiency, exceeding between 75 and 90% efficiency.
- Solid biofuels are recognized and have their own treatment in the international and national norms

BIOMASS THERMAL USE PROS and CONS

Wood pellets

- PROS:

- High calorific value.
- Very low ash content, reducing operation and maintenance needs.
- Pellet boilers are very high efficiency, there are even pellet condensing boilers.
- They are traded internationally, with a constant composition.
- They are used with standard compositions in Europe.

- CONS:

- High price compared to other biomasses.

- Considerations:

- Requires storage in an isolated and dry place.
- It does not need any type of drying or treatment once produced.
- They are standardized, so they have high operation reliability and less effort for the operation and maintenance of the boiler. However, their cost is high due to the treatment to which they are subjected in their preparation.

BIOMASS THERMAL USE PROS and CONS

Wood chips (both class 1 and class 2).

- PROS:

- Their production cost is lower than that of pellets due to the lesser processing required.
- Clean bark and dry chips (class 1) are normally of high quality.
- It has a medium degree of standardization at European level.

- CONS:

- They are less dense than pellets and olive pits and therefore require more space for storage.
- Being less dense, transport is only justified up to a short distance (< 50 km).

- Considerations:

- Their composition is variable.
- The raw material must be dried naturally or artificially to a humidity of less than 45%, or even less than 30% in the case of the best class 1 chips.
- They have an ash content of less than 1% (class 1) or 5% (class 2).

BIOMASS THERMAL USE PROS and CONS

Agro-industrial waste

- PROS:

- Availability and types (abundance of products and quantities).
- Large productions in agricultural countries.
- Their production cost is lower because they are by-products of a process.
- They usually have a high calorific value, but caution must be taken with the quality of the biomass to be acquired, avoiding biomass with unwanted residues.

- CONS:

- Its ash content, although acceptable, is higher than that of pellets, so maintenance work will tend to be greater.

- Considerations:

- They can be seasonal biomasses, so their supply, if directly from the producer, should be agreed upon during the season.
- Variable composition

BIOMASS THERMAL USE PROS and CONS

Firewood and briquettes

Its use is infrequent and practically exclusive for small boilers with a medium degree of automation, since it is necessary to introduce firewood or briquettes several times a day (the days of higher consumption). The production cost of briquettes is much higher than that of firewood, although the calorific value of the former is clearly higher. In addition, briquettes produce less ash, facilitating the cleaning and maintenance of the boiler.

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Introduction to the biomass technology: from fuel sourcing to thermal use

INITIAL CHOICES FOR LEBANON

Biomass fuel issued by:

1. Residues from forestry fellings
2. Residues from fruit and olive trees
3. Stones, shells and husks

Transformed in Briquette and Pellets

To thermal use by STOVES and BOILERS

1. Briquettes to be used in traditional stoves and boilers
2. Pellets to be used in new/adapted stoves and boilers

State of the technology

PELLETS STOVES

- Wood pellets are small, cylindrical, standardized pressed pieces of natural, untreated wood about 2 cm in size..

- The energy content of 2 kg of wood pellets corresponds approximately to 1 liter of heating oil.

- Pellets are sold in different formats: 15 kg bags (sufficient in the case of domestic pellet stoves), big bags or in bulk (for large biomass boiler consumption).

State of the technology

Advantages of pellet stoves

- They use 100% renewable fuel (pellets), which also offers a competitive and stable price compared to fossil fuels.
- The pellet is characterized by its high calorific value, homogeneity and constant composition, which allows very high energy yields.
- In addition to heating the air naturally, the stove emanates a very pleasant radiant heat.
- The control is electronic. Thanks to the use of digital and programmable thermostats, this type of heating can be regulated even remotely from the Smartphone.

State of the technology

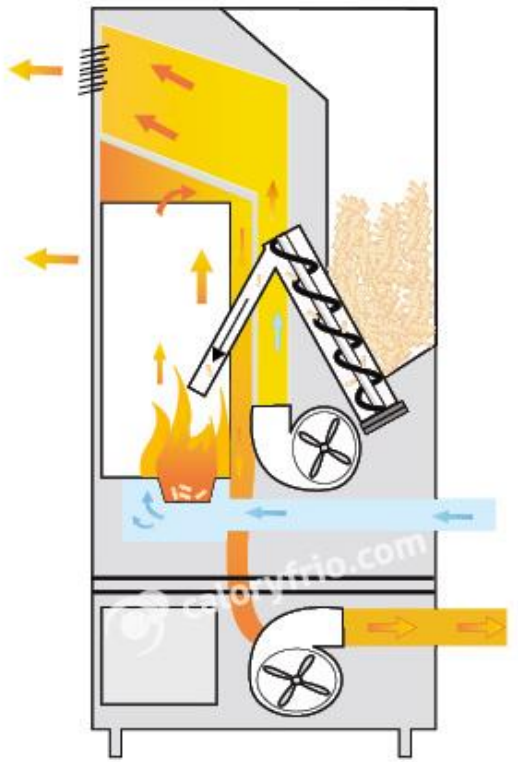
- How do pellet stoves work?

The pellets are automatically fed from the tank directly into the stove. When the first pellets burn, the firebox ventilation is started, passing a jet of air through the ash pan in order to fan the flame.

The stoves have several heat sensors to start the heat exchanger ventilation in order to draw the heat out of the stove.

After ignition, the stove enters normal operating mode by loading the ash pan with pellets and venting the chamber.

The stove will start heating again when the temperature has dropped below the desired temperature. The stove heats mainly through its adjustable ventilation



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State of the technology

Three types of stoves

Forced air stoves	Ductable stoves	Hydro stoves
From 4 kw **Fan expels hot air** **Different flame and fan powers** **Large espaces without room distrib** **Safety system for over-temperature**	**To distribute hot air to # rooms** **Expel hot air through the front, or divert it to any of the outlets.** **Homes with many rooms/floors**	**Heating water to any radiators network** **Can exceed 25 KW** **Like small boilers, needs circulating pumps, expansion vessel…**

State of the technology

How much power do I need?

- Domestic pellet stoves do not have large powers so they are generally used as a complement to another heating system or to heat specific rooms
- A formula for calculating the power in kW of a pellet stove is:

- ***Pellet stove power= Room volume (m3) x Coefficient (kW/m3)***.

- Coefficient will depend on the type of insulation of the house and its climate zone (cold or warm).

Values for Spain :

Cold climate and good insulation = 0.05 kW/m3. Cold climate and medium insulation = 0.065 kW/m3 Cold weather and poor insulation = 0.08 kW/	Warm weather and good insulation = 0.04 kW/m3. Warm weather and average insulation = 0.045 Warm weather and bad insulation = 0.05 kW/m3.

- Example : rooms to heat of 70 m2 of surface, height 2.70 meters.
  - Cold Weather and good insulation (Lebanon border) you'll need around 9,45 kw Stove
  - Warm weather and good insulation (Lebanon coast) you'll need around 7,56 kw Stove

State of the technology

PELLETS BOILERS

Biomass boilers (Bb) use natural fuels as an energy source as heating materials, such as wood pellets, olive pits, forest residues, nut shells, etc.

Bb generate heating (radiator, air or underfloor heating) and hot water for a house or residential building.

They are considered the most environmentally friendly combustion boilers on the market.

Operating principle

State of the technology

- Low power boilers: Boilers are used to generate heat that can then be transferred to a working fluid (typically water, in domestic premises) to supply space heating circuits and/or domestic hot water circuits. Low power boilers range from 6-60 kW and are recommended for single-family houses or small buildings. The main benefit of these boilers is their reduced size, high efficiency and low cost.
- Medium power boilers: Medium power boilers range from 60-150 kW thermal output and are designed to supply heat to residential buildings (apartment blocks) or office buildings.
- High power boilers: High power boilers range from 200-800 kW thermal output and are designed to supply heat demands of industrial processes.
- Thermal power stations: Thermal power stations have capacities of 1 MW or above, and they are built to produce and supply heat to several nearby facilities or district heating networks.

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State of the technology

- Biomass boilers have applications that can be both domestic and industrial, In addition, they can be installed in cascade so they can reach powers close to a megawatt to provide heating and hot water to hotels, public buildings, residences, schools, residential buildings, heat networks, industrial manufacturing processes, rural houses, etc. resulting an ideal option for the rural environment.
- In addition, to optimize the operation of the biomass boiler, we can install an accumulator, which will store the heat in a similar way to a solar energy system.
- Biomass boilers need a container or silo for biofuel storage located next to the boiler. From the silo, a screw or suction feeder takes it to the boiler, where combustion takes place. The pellet type fuel must be stored with an inclination of about 45º for its correct insertion in the boiler. The development of storage systems means that they are increasingly better integrated architecturally.
- When biomass is burned, some ash is produced, which is generally collected automatically in an ash pan that must be emptied several times a year.

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State of the technology

What type of biomass boiler to choose?

- The selection of the boiler, the storage system and the transport and handling system are conditioned by the choice of the type of biomass to be used.
- Some boilers allow burning more than one type of fuel (**polyfuel boilers**) while others must work with a specific type of fuel, as in the case of pellet boilers. In the case of polyfuel boilers, they require a greater storage capacity since they are larger and more powerful, generally intended for industrial use

With different combustión chambers for each fuel (firewood, pellets)

Same combustión chambers for different fuels with similar size (pellet, olive pits)

State of the technology

Pellet boilers

- To generate heating and domestic hot water by accumulator for homes up to 500 m2.
- Only fed with uniform fluid type fuels specifically designed for them (pellets)
- Feeding by pellet buffer tank or a silo, using a screw
- Efficiency near to 90%, main improvement in boilers technology, by accurate management control elements
- Performance comparable to boilers of other energy sources, with very low pollutant emissions

State of the technology

Wood Chip boilers

- Higher power ratings and a smaller number of manufacturers, for industrial or big district heating
- Only fed with uniform fluid type fuels specifically designed for them (chips, husks…)
- Automatic feeding and operation by chips silo, using a screw
- Efficiency near to 100%, main improvement in boilers technology, by accurate management control elements
- Performance conditioned by humidity of chips.

State of the technology

Advantages of boilers

- The price of biomass, more stable and economical
- The price does not depend on international markets as fossil fuels, because biomass can be generated from local resources
- Biomass is the fuel with the most competitive price for the user, and, therefore, a biomass boiler brings profitability and economic comfort
- It is a safe and advanced technology.
- Biomass boilers use a safe technology that requires easier maintenance
- Average boilers reach easily 90% of efficiency. New boilers can reach 100%.
- CO2 Neutral emission because renewable natural fuel
- The extraction of forest biomass helps to clean the forests (preventing fires)
- Biomass is also a source of employment in rural areas and is environmentally friendly.

State of the technology

Disadvantages of biomass boilers

- Lower calorific value
- Compared to fossil fuels, one kilogram of pellets has half the calorific value of one liter of diesel. In a pellet boiler, we will need two kilos of pellets or olive pits to produce the same energy as a liter of diesel.
- It needs a large storage space
- One m3 of pellets weighs approximately 650 kg. Thus, if in a year you consume 2,000 liters of diesel you will need about 4,000 kg of pellets or olive pits, which will occupy approximately 6 m3. Biomass boilers need a silo for fuel storage located next to the boiler. This silo is recharged periodically by the user himself or by the biomass dispensing company contracted for this purpose.

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Potential raw material in Lebanon

Ranking of bioenergy streams in Lebanon (The National Bioenergy Strategy for Lebanon)

- 1.Residues from forestry fellings
- 2.Residues from fruit and olive trees
- 3.Residues from cereals
- 4.Energy crops on currently unused land
- 5.Olive cake by-products
- 6.Waste wood
- 7.Municipal sewage sludge
- 8.Animal fat and slaughterhouse residues
- 9.Yellow grease
- 10.Landfill gas recovery (specifically Naameh landfill)

Ranking of bioenergy streams in Lebanon (colour coded)

	Biomass resources	Primary energy potential (TJ)	Energy potential	Sustainability	Accessibility	Legal framework	Ranking
Forestry	Woody biomass and fellings	1,852 - 2,510					Not ranked
	Residues from fellings	1,378 -1,771					1
Wood and paper industries	Wood residues from sawmilling, wood-working, furniture industry	0					Not ranked
	By-products from paper industry	0					Not ranked
Agriculture	Residues of olive trees	842 - 968					2
	Residues of fruit trees	2,110					
	Residues of Cereals	2,116 - 2,233					3
	Manure	1,500					Not ranked
Energy crops	Jatropha	491 - 3,051					4
	Miscanthus	464 - 1,857					
	Eucalyptus	445 - 1,780					
	Sunflower	184 - 296					
	Giant Reed	1,990 - 3,180					

Ranking of bioenergy streams in Lebanon (colour coded)

	Biomass resources	Primary energy potential (TJ)	Energy potential	Sustainability	Accessibility	Legal framework	Ranking
Food processing industry	Animal fat	258					8
	Slaughterhouse residues	495					
	Olive cake by-products	460 - 1,083					5
	Organic residues and waste from food processing industry	N.A.					Not ranked
	Wastewater and sludge from food processing industry	0					Not ranked
Municipal solid waste and non-hazardous industrial wast	Biodegradable fraction of municipal solid waste	2,011					Treated separately
	Landfill gas recovery potential	585					10
	Industrial and commercial waste	N.A.					Not ranked
	Waste wood	583					6
	Municipal sewage sludge	666					7
	Landscape management residues	15					Not ranked
	Yellow grease	495 - 562					9

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Potential raw material in Lebanon

PROPOSED CHOICES FOR LEBANON

Biomass fuel issued by:

1. Residues from forestry fellings	Amending forestry laws to encourage forest management including cutting trees in a raisoned maner, to prevent forest fires
2. Residues from fruit and olive trees	Ressources need to be well evaluated and market encouraged
3. Stones, shells and husks	Users are familiar with this fuel, but new boilers/stoves performance need to adapt the collection, treatment and management
4. Wood waste	As any waste becoming “by-product”, new value can generate economical interest

Transformed in Briquette and Pellets, or consumed directly like almond husks or olive pits

To thermal use by STOVES and BOILERS

1. Briquettes to be used in traditional stoves and boilers
2. Pellets to be used in new/adapted stoves and boilers
3. Husks and olive pits as a component of briquettes/pellets or burned directly in stoves/boilers accepting this fuel

Thank you!

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