FORESTRY BIOMASS AS A FEEDSTOCK FOR ENERGY PRODUCTION IN CHILE: CHALLENGES AND OPPORTUNITIES

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Abstract: Chilean forestry industry in based on more than 2 million ha of pine and eucalyptus plantations, subject to 25 and 11 years rotation cycles. Additionally, there are 13 million ha of native forests which are not used industrially, due to strict conservation legislation. There is an urgent need to use biomass as a source of heat and power, to meet growing energy needs in the country. Both, biomass residues from current forestry activities and fuelwood from energy plantations could provide enough energy resources to meet part of future needs. Forestry activities generate around 500.000 ton biomass residues every year, whereas energy plantations settled on unused land could provide 60 million ton biomass. Government incentives and R&D would be required in order to attract investments, protect the environment, and maximise positive social impacts.

INTRODUCTION

The Chilean economy is growing at a steady rate, and is expected to do so for the foreseeable future. Over the last decade, the GNP increased at around 3.7% per year, and so did energy consumption. Currently, energy consumption in Chile is equivalent to 26 millions ton oil equivalent per year, with 1.6 ton oil equivalent per capita year. Nearly 75% of primary consumption comes from imported fossil fuels, whereas 20% is met by wood burning, mostly for heating purposes.

Despite current efforts to increase the efficiency of energy usage, energy demand is expect to grow due the fast growing economy and population. Given the significant forestry resources, energy from biomass could offer an interesting option to reduce the current vulnerability of the Chilean energy matrix.

Moreover, the Chilean forestry industry is well established and accounts for 3.5% of GNP, and 11% of total exports. This industrial sector is based on 2.1 million ha of pine and eucalyptus plantations. In this paper, a brief review of the energy potential from biomass is presented. Firstly, forestry resources and energy consumption in Chile are briefly reviewed. Then, the potential of biomass as feedstock for energy uses is discussed. Finally, key challenges are identified.

FORESTRY RESOURCES IN CHILE

Chile features a continental surface area of 756,250 km^2. Native forests cover around 13.4 million ha, representing 18% of the country's territory. As shown in Table 1, most native resources are evergreen and Nothofagus species, located in southern Chile. Standing biomass in native forests is estimated at around 1.1×10^9 m^3, whereas 12 million m^3/year are extracted for local fuelwood purposes.

On the other hand, forestry plantations cover over 2.1 million ha, mostly planted with *Pinus radiata* and *Eucalyptus globulus* species (see Table 2). It must be mentioned that all biomass supply to the Chilean forestry products industry comes from forestry plantations, featuring rotation cycles around 25 and 11 years for pine and eucalyptus, respectively.

Table 1. Predominant Native Species (UACh, 1999)

Native Forestry Species	Covered area (ha)
Evergreen	4.140.000 ha
Lenga (Nothofagus pumilio)	3.392.000 ha
Coigue (Nothofagus betuloides)	1.793.000 ha
Roble (Nothofagus oblicua)	1.461.000 ha

Table 2. Eucalyptus and Pinus Regional Distribution (Infor, 2006)

Region	Eucalyptus (ha)	Pinus (ha)
Coquimbo	2.634	-
Valparaiso	39065	10.903
O`Higgins	34.169	66.380
Maule	38.196	389.434
Bio Bio	240.473	610.296
Araucania	168.019	263.326
Los Rios	61.067	106.765
Los Lagos	42.184	15.237
Aysen	-	23.564
Total	625.807	1.462.341

THE CHILEAN ENERGY MATRIX

As seen in Table 3, the Chilean primary energy matrix shows that fossil fuels account for nearly 73% of total energy consumption, whereas biomass reaches less than 20%. Therefore, the country is extremely vulnerable to variations in oil, gas and coal prices and availability at international markets.

Hydroelectric resources are mostly located in Southern Chile. However, during the last century there has been a sustained reduction in rainfall due to climate change, affecting electricity generation. Additionally, Chile is periodically affected by the El Niño-Southern Oscillation. During La Niña event severe droughts reduce water availability for electricity generation, increasing the pressure on thermoelectric power generation. This trend is expected to continue and, even, become more severe.

Table 3: Chilean Primary Energy Matrix (CNE, 2007)

Primary Energy Source	Tcal /year	%
Crude Oil	106.155	41
Natural Gas	42.718	16
Coal	42.861	16
Hydroelectricity	19.576	8
Fuelwood	49.841	19

The country's electricity grid is divided into two major interconnected systems (see Table 4). The Northern grid has a total capacity around 3.2 GW mostly from thermoelectric power plants. The other serves the Central-Southern part and features 10 GW, 60% from hydroelectric and the rest from thermoelectric plants. Thermoelectric plants are fuelled by imported coal and natural. Additionally, there are 0.4 MW electricity generation capacity, from CHP fuelwood boilers in pulp and paper mills.

Table 4: Electricity Grids in Chile (CNE, 2007)

Interconnected Grid	Installed Power Capacity GW	Primary Energy Source
Northern SING	3.6 GW	99% thermo
Central SIC	10.0 GW	40% thermo 60% hydro
Others	0.1 GW	88% thermo 9% hydro 3% wind
Total	13.7 GW	

FORESTRY BIOMASS AS ENERGY FEEDSTOCK

Biomass residues from forestry plantations

As seen in Figure 1, around 14 million ton/year woody feedstock (dry basis) are harvested every year. Main products include 5 million ton cellulose, and 3 million ton saw wood and boards. Part of woody residues produced in sawmills are used as raw material for cellulose production, and the rest is used as fuel for steam generation. Cellulose mills also generate electricity for internal uses and the surplus power is fed to the national grid.

On the other hand, forestry activities also generate large amounts of residues. Pruning and thinning produce 150,000 and 100,000 ton/year biomass residues. These add to around 1 million ton residues produced during harvesting (Bidart, 2007). Part of harvesting biomass residues are burnt to reduce volume, incorporated into the soil, chipped, or used as fuelwood. Biomass residues from forestry activities that could be potentially used for energy purposes are estimated around 500,000 ton/year

Energy Plantations

Current estimations indicate that there are around 10 million ha unused or erosion stricken land available for forestry activity, mainly in Southern Chile. Energy plantations appear as an interesting alternative to stop erosion and reclaim soil. Fast growing species, such as eucalyptus or poplar, could yield around 20 ton/year per hectare. Considering a plantation area of 2 million ha, then 40 million ton/year, ie. 150,000 Tcal/year representing an energy equivalent of 3 times current biomass fuels and 35% current coal imports.

Additionally, appropriate forest management practices could enable a yearly supply around 5 ton surplus biomass per hectare, from native forests. Considering an area of 4 million ha, then 20 million ton biomass / year could be cropped, representing ie. 75,000 Tcal / year

In total, those biomass sources would provide an equivalent to 50% current coal imports.

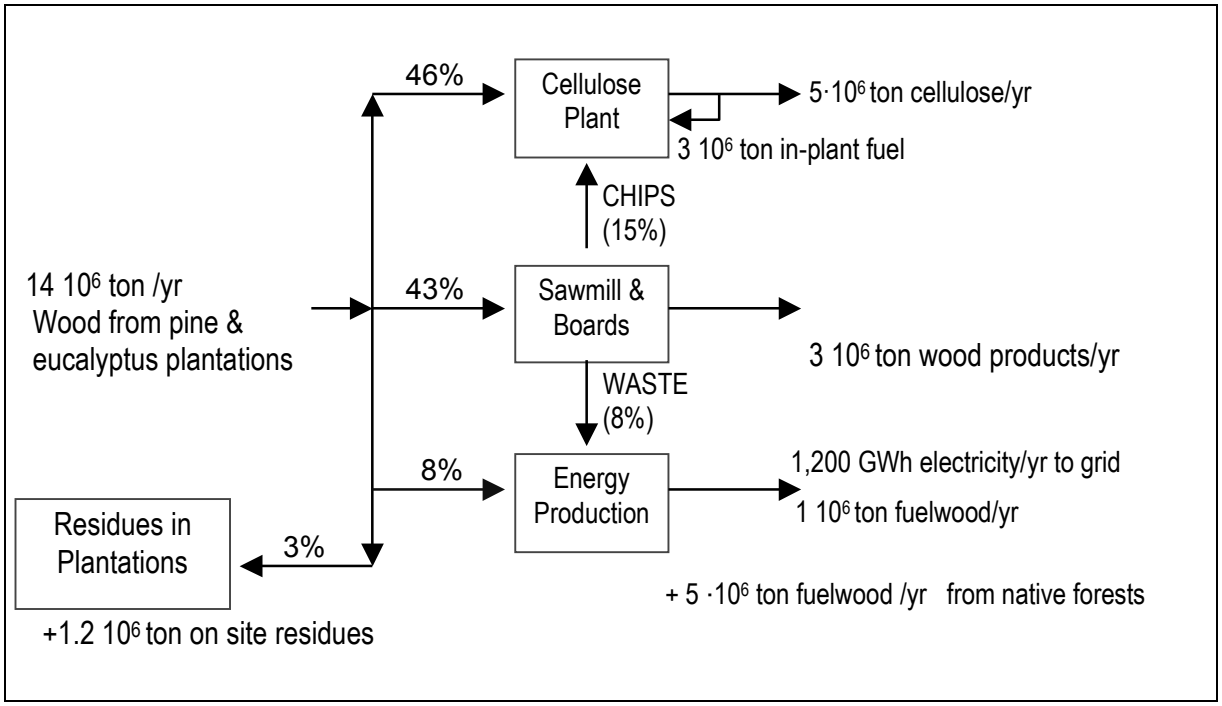

Figure 1: Forestry Sector Mass Balance

Agricultural Residues

Chilean agriculture accounts for 0.7 % GNP, with a total arable land around 700,000 ha, where 40% is used for wheat and oat crops. Almost all arable land is committed to food production (grains, fruits, vegetables), and there is little land available for energy crops. Agricultural residues are estimated around 1.5 million ton/year, representing a maximum energy potential of 45,000 Tcal /yr.

Key Challenges

In order to achieve an effective implementation of energy-from-biomass policies in Chile, Government incentives are required to promote sustainable energy plantations. For example, tax reductions and direct incentives to reforestation aimed at enhancing energy plantations, and provide long term rural employment, are a key to attract investments. Additionally, financial and technological support is essential to maximise positive social effects and minimise negative environmental impacts.

On the other hand, transport costs represent a serious problem. Indeed, most urban-industrial centres are located in Central Chile (30–37ºS), whereas available forestry land is in Southern Chile (40–50ºS), with distances in the range

400 – 2000 km. Moreover, forestry residues feature low density and high moisture content. Therefore, there is a need for decentralised processing, and/or in-situ densification or concentration (e.g. Bio-oil, charcoal, pellets).

Technological, R&D and social-environmental issues constitute key challenges that must be taken into consideration in the design and implantation of energy strategies. Some are listed below:

Technological Challenges:

- Decentralised processing, in-situ densification
- Thermal conversion technologies (pyrolysis, gasification, etc)
- Replacement of old inefficient stoves, for thermally efficient systems for cooking and heating
- Improvement of thermal insulation in construction
- Improvement of fuelwood specifications (limits to moisture content)
- Efficient environmental control technologies (air pollution control, ash management).

Research and Development Issues:

- Selection of appropriate lignocellulosic feedstock (according to growth rate, yield, energy value, environmental requirements, and chemical composition).
- Appropriate energy conversion / usage technologies (start from low complexity, and low investment costs).
- Integration of biomass energy into existing forestry practices and industrial wood processing.

Environmental and Social Issues:

- Prevent reduction of biodiversity, and negative impacts on fragile ecosystems.
- Greater controls on fertiliser use and N_2O emissions.
- Use fossil fuels only when no other alternative exists.
- Policies to favour sustainable native forest management.
- Favour labour intensive systems to maximise impact on rural employment.
- Adapt labour legislation as required.

- Financial support to small entrepreneurs, to achieve greater local social impacts.

CONCLUSIONS

There is a need for greater diversity of energy sources, to reduce imported fuel supply risks and vulnerability of hydro-electric resources. Fast growing forestry plantations may help to increase the use of biomass for energy production purposes (CHP). On the other hand, economic incentives are required to support the settlement of energy plantations, and to introduce energy conversion/use technologies. Last, but not least, social and environmental issues have to be taken into consideration in the design of energy policies.

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