4. Gasification

SECTOR: ENERGY	
TECHNOLOGY: Gasification	
Introduction	The Central American country of Belize has an area of 8,867 square miles (22,960 km²) and approximately 330,000 people (2010 census). This results in one of the lowest population densities in the world and as such, there are a number of isolated communities that are not connected to the national power grid. There are also several entities such as eco-hotels that rely on electricity generated from non-renewable fossil fuels. Gasification is the partial oxidation process that uses a carbon source such as coal or biomass to produce carbon monoxide (CO) and hydrogen (H_2), plus carbon dioxide (CO_2) and possibly hydrocarbon molecules such as methane (CH_4) which are otherwise known as syngas or synthetic gas. This factsheet will focus on biomass gasification to produce electricity using small modular gasifiers – in particular the APL Power Pallet PP 20 unit. This unit integrates a gasifier, an internal combustion engine and a electricity generator.
Technology characteristics	Gasification is a series of chemical reactions, which take place in the controlled environment of a gasifier. There are multiple types of gasifiers and the model chosen is dependent on the feedstock to be gasified. The normal process of gasification can be broken down into various stages: i. Biomass fuel is heated in a reduced oxygen gasifier chamber to about 100 °C under high pressure (about 1000 lbs. per sq. in.) so that drying occurs. ii. Pyrolysis follows at 200-300 °C. During pyrolysis, volatiles in the form of gas and liquids are off gassed and solid char rich in carbon is left behind. It is this char that will undergo gasification reactions. iii. Combustion occurs as the previously produced volatiles, along with some of the char, reacts with limited amounts of oxygen. This creates carbon dioxide and small amounts of carbon monoxide. The combustion provides heat for the subsequent gasification process to occur. iv. Gasification happens once the char starts to react with carbon and steam to generate carbon monoxide and hydrogen. It is this mixture of carbon monoxide and hydrogen, which comprises syngas. Whatever parts of the fuel are not converted, are reduced into charcoal and tar, and fall into an ash bin. The syngas can then be combusted to generate electrical or mechanical energy or as feedstock to manufacture fertilizers, pure hydrogen, methane or liquid transportation fuels. The solids and liquids left behind are called charcoal and

tar which are then used for soil augmentation.

The APL Power Pallet PP 20 is a complete biomass power generation solution that converts woody biomass into electricity. The APL PP 20 is a compact and fully automated system - from biomass to electricity generation. The following are the main performance characteristics of the Power Pallet PP 20:

Continuous Power Rating:	18 kW @ 60 Hz 120/240 VAC
Biomass Consumption:	1.2 kg/kWh, 2.5 lbs/kWh
Run Time per Hopper Fill: approximate @ 250 kg/m^3 fuel density	5 kW: 10 hrs 10 kW: 5 hrs 15 kW: 3 hrs
Max. Continuous Operation:	>12 hours
Start Up Time:	10-20 min.
Installed Footprint:	1.36 x 1.36 m 53.5 x 53.5 inches

The Power Pallet uses agricultural and forestry waste materials that can be readily sourced very near the point of generation. The following are the feedstock (biomass) characteristics:

Feedstock Size:	12-40 mm/0.5-1.5 in.
Moisture Content:	5-30% dry basis
Approved and Tested w/ normal operating procedures	Nut Shells (e.g. Walnut, Hazelnut) Softwood Chips (e.g. Fir, Pine) Hardwood Chips (e.g. Oak, Ash)
Approved and Tested w/ increased operating effort	Corn Cobs Coconut Shells Palm Kernel Shells
Not Approved dangerous & voids warranty	Coal Tires Plastic Municipal Solid Waste

Costs, including cost to implement mitigation options	The APL Power Pallet PP 20's acquisition cost is approximately US$ 25,000. Additional costs will be incurred to ship, import and install the unit which is estimated to be US$ 10,000.
Cost of not modifying the project	To generate 20 kW from a conventional fossil fuel (diesel) burning generator. The cost of this type of generator installed is approximately US$ 20,000.00. Over an entire year of operation at an average of 12 hours per day, equates to approximately 7000 gallons of fuel. And at an emission rate of 22.2 lbs./gallon of diesel. This plant will emit approximately 154,000 pounds of CO_2 per annum. Coupled with the cost of the fuel at US$ 4.00 per gallon. The annual

<table>
<tr><td></td><td>operating cost will be about US$ 20,000.00 in fuel and maintenance costs.</td></tr>
<tr><td colspan="2">Potential development impacts, benefits</td></tr>
<tr><td>Economic</td><td>Costs, employment, investment, other:

The viability of this unit is heavily weighted on the availability and cost of appropriate feedstock. Based on the feedstock options presented in the above table, Belize’s most abundant feedstock would be softwood and hardwood chips as well as coconut shell and palm kernel shells. The following table compares the operating costs of fossil fuels versus gasified biomass:

<table>
<tr><td>Diesel/LPG</td><td>US$ 0.40 - US$ 0.75/kWh</td></tr>
<tr><td>Gasoline</td><td>US$ 0.50 - US$ 1.00/kWh</td></tr>
<tr><td>Gasified Biomass</td><td>US$ 0.00 - US$ 0.20/kWh</td></tr>
</table>

Note that these are in US dollars and calculated when the world market price for crude oil was at US$ 50 per barrel.

Note that the feedstock should be of a certain size, 0.5 in to 1.5 in – as such some pre-processing must occur. Depending on the feedstock shredders and wood chipper range in price from US$ 300 for small unit that can handle trees up to 3 inches in diameter. The cost for larger units that can handle 12-inch diameter trees is approximately US$ 20,000.

The employment potential for this unit will vary greatly. It will depend on its location, if it will be used to generate electricity for a remote resort or community. Locals can be hired to provide biomass fuel for the system on a regular basis.</td></tr>
<tr><td>Social</td><td>Income, education, health, other:

Income generation for this technology in unknown. Note however, that the potential is there for earnings to be generated from the sale of electricity.

This can in term be passed on for the purchase of feedstock from local farmers.

Education will have to come in the form of training of operators of the system. Much like training of operators for water systems.

Health issues as it relates to the operation of the gasifier will be mitigated with the training that must be received form the equipment supplier.</td></tr>
<tr><td>Environmental</td><td>Local pollution, GHG emissions, other.

Gasification units such as the Power Pallet PP 20 are recognized as carbon negative units. Here are the specifics of the accounting for a Power Pallet PP 20 running for 3,500 hours per year at 15 kW electrical output, and consuming 1.2 kg/kWh of fuel:

Output 53 megawatt hours per year (MWh/yr) of electricity (secondary energy)</td></tr>
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	Consume 63 metric tons per year (tonnes/yr.) of biomass Sequester 3 tonnes carbon/yr. or 11 tonnes CO_2 /yr. (assuming 5% by input mass carbon sequestration) Offset from 15-93 tonnes CO_2 /yr. compared to use of fossil fuel for electrical generation. It should be noted that the carbon emissions from the peripheral activities such as wood chipping and transportation were not accounted for. For example, the average Caribbean pine tree with a height of 20 m and diameter of 0.3 m, can provide the gasifier with an output of 15 kW for 8 days @ 12 hour runs per day.
Status	There are no known gasifiers in the country of Belize presently.
Barriers	- *include barriers to implementation and issues such as the need to adjust other policies to accommodate the adaptation option* The main barriers to the implementation of this mitigation technology include i. Capital cost of gasification unit and peripheral machines (wood chipper). ii. Sourcing large quantities of cheap and appropriate biomass. iii. The work required to find, cut, and process the biomass so that it becomes suitable for use. iv. This technology is quite specific, not known locally and not well known internationally. It will require extensive training of stakeholders from specialized trainers. v. A possible negative social and environmental outlook on the technology for the need to cut trees to supply the plant.
Acceptability to local stakeholders	*Not all adaptations technologies will be equally attractive to all stakeholders for political, economic, social, or, a cultural reason.* The acceptability will vary depending on the stakeholder. It is believed that the main issue will come from the fact that trees will be used to power the unit. To counter these negative views, it is being suggested that any community/entity that implements this technology, also commence a tree replanting programme, where for each tree that is cut down, five trees are planted in its place. This will provide additional employment for local communities and stimulate the local economy.
Endorsement by experts	*In some countries decision-makers will partly base their selection on consistency of proposed mitigation options with international best practices*. There are currently no endorsements for this technology. However, the Ministry of Energy has expressed interest in gasification technology, and can help

	promulgate it among potential stakeholders.
Timeframe	*Specify timeframe for implementing the technology* The specific timeframe for implementation of this technology would be 6 – 8 months. However, monitoring and evaluation should extend for a year or two to assess its sustainability.
Institutional capacity	*How much additional capacity building and knowledge transfer is required for the adaptation option to be implemented* Training for the implementation will need to come from the supplier of this technology, namely the suppliers of the Power Pallet PP20, in coordination with the Ministry of Energy, Technology, Science and Public Utilities.
Adequacy for current climate	*Are there negative consequences of the mitigation option in current climate?* Villages that are not connected to the national power grid, but use a diesel generator set to power its water system can use this technology. Small remote hotels and military outposts that are not connected to the national grid can use this technology to supplement their current energy system (including charging and maintenance of solar PV battery pack).
Size of beneficiaries group	*Mitigation technologies which provide small benefits to large numbers of people will often be favoured over those that provide larger benefits, but to fewer people.* The size of beneficiary groups includes the villages of: San Benito Poite, population 550; Jalacte, population 780; Pueblo Viejo, population 450. Also, proprietors and workers of small industrial establishments, hospital and eco-tourism resorts and hotels.

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