**Crude biofuel for potential off grid remote power generation using waste biomass feedstocks: A feasibility analysis for the case of Botswana.**

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**Highlights**

* There are a number of isolated communities in sparsely populated Botswana with no access to electricity; their connection to main grid deemed very uneconomical.
* Only explored alternative has been solar, meanwhile there is a large resource of waste encroacher biomass which can be used.
* Exploring pyrolysis alternative where the bulky thorny bushes are pyrolysed on site to increase energy density before being transported to a slightly modified sterling engine that can be a stand alone power generator or part of a hybrid system
* Thermochemical characterization for acacia undertaken.

**1. Introduction**

The case of access to electricity for remote areas has always been topical, especially for developing nations where the energy poverty translates to retarded development for such communities. Botswana is one such nation that has scattered, isolated and sparsely populated settlements where the extension of the main grid is uneconomical. Close to about 43% of rural and 25% of urban households in Botswana have no access to electricity {Formatting Citation}. Most attention has been directed at powering remote off-grid communities using renewable sources like solar, which are accessible everywhere; however, not much attention has been paid on emerging renewable sources like 2nd generation biofuels from lignocellulosic waste. Coincidentally, Botswana is home to notorious woody encroacher species that are costing the government and communities millions of dollars annually through depleting pastures and subsequently livestock productivity [1]–[3]. Some of the money is spent in debushing exercises to restore the aesthetic appeal in cities, towns and villages, since these drought resistant coppices spring up everywhere. Meanwhile nations like Namibia have turned the woody encroacher nuisance into value through very profitable renewable energy ventures like charcoal [4]. This feasibility analysis which is focused on alleviating energy poverty in remote settlements explores all the possible power generation alternatives that could use the encroacher biomass, especially after converting it into a crude biofuel (bio-oil). Relatively simple technologies that can be run within such contexts are explored. Carbonization techniques for raw biomass, pyrolysis and simple upgrading of oil, various power generation alternatives and hybrid options with prevalent renewable energy initiatives are examined and compared. A preliminary economic feasibility check is done.

**2. Methods**

Since this is mostly a feasibility analysis, the major avenues of ascertaining facts is being done through desktop studies, interviews of remote community leaders and relevant civil society stakeholders. Economic feasibility is being done by comparing with similar plants and checking prices of equipment from vendors. Thermochemical characterization was done using equipment for elemental analysis, thermogravimetry and calorimetry.

**3. Results and discussion**

The results so far obtained pertain the properties of the biomass encroacher species, *Acacia Tortillis*, which is one of the major encroacher bushes. These characterization results help to map the conditions and resulting products for thermochemical conversion processes.

**Table 1.** Results from thermochemical characterization

|  |  |  |  |
| --- | --- | --- | --- |
|  | Ultimate analysis- average of 2(Thermo scientific flash 2000 CHNS-O analyser ) | Proximate analysis (Dry basis)- averages(Thermogravimetric analyser- Leco TGA 701) | **HHV** (MJ/kg)Bomb CAL2K-2 |
| % | C | H | N | Oa | Ash | FC | VM | MC |  |
| ACACIA | 41.47 | 5.15 | 1.23 | 52.15 | 3.90 | 19.59 | 76.51 | 3.72 | 17.267 |
| PINEDUST | 45.76 | 5.54 | 0.039 | 48.66 | 0.83 | 20.00 | 79.16 | 65.41 | 17.568 |

The moisture and ash contents are within acceptable limits; while the high volatile matter typical for lignocellulosics shows a high potential for bio-oil generation. The relatively higher ash (compared to Pine) in the feedstock will report to the bio-oil affecting its stability although the margin of effect would still need to be determined.

**4. Conclusions**

The thin stems of most of the shrub encroachers from debushing exercises are not eligible for charcoal production, the method largely used by Namibia to valorize its large waste encroacher inventory. The larger trees from rangelands can be converted into charcoal; however construction of even mini power plants to use solid fuel for combined heat and power generation will not be very cost effective for smaller populations. An autothermal pyrolysis plant, possibly integrated with solar, can be a quick alternative requiring less sophisticated technology and expertise. A modified sterling engine can be used to generate power from the pyrolysis oil.

**References**

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