# Biomass Data Request

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## 1 Introduction

This note is intended for Håkon Duus and Geir Kulia which will be collecting data for the micro-grid design, that will supply the dormitory belonging to the College of Science and Technology, Phuentsholing, Bhutan. Specifically this will involve the parameters concerning the biomass generator. In this note I will include a quick introduction to two solutions available for biomass power generation, and my thoughts of these systems utilized in our context. Further I will list the data which I deem relevant data for evaluating the final solution. The intention of producing a elaborate note is so that Duus and Kulia may know the thoughts behind each request, so that they may contribute to the solution if the opportunity arises, and so that the authors lacking perspective might be compensated for. Please notice the references to further discussion in the text, as they are more or less important.

## 2 Necessary Assessments

### 2.1 Estimated scale

I have written a script that extracts some key numbers from the logplot.m script that is used to dimension the different components of the micro-grid. Assuming that these data are correct these are the results i scale my system by. You can read the parameters of the simulation below [1]. The data of which i base my request are the following:

```
============================================================
SIMULATION DATA FOR ANALYSIS
============================================================
Optimal battery size [kWh] = 1400
Optimal PV array size [kW] = 320
Budget = 800000
Accepted LLP = 6.4767%
Min/max battery = 1100/1600
```

[1] I have not merged optimization with generator and PV combined solution

```
Min/max PV = 250/400
Step PV = 5; Step battery = 10
=========================================================

Totals:
Total time offline: 427
Total occurences offline: 56
Total kWh default one year: 12607.96

Averages:
Average time offline during LL period: 7.625
Hourly average kWh defaults during one LL period: 29.5268
Daily average default: 34.5424 [kWh]
Monthly average default: 1050.6633 [kWh]
Weekly average default: 242.4608 [kWh]
Average increasing kW demand during LL period: 16.1477

Worst-Cases:
Largest kW demand during LL: 131.3162 - at time: 6535
Longest time offline: 12 - at time: 4041
Sum kWh during longest offline: 391.0048
Largest daily default: 447.4534 - at day: 215
Largest weekly default: 1483.4515 - at week: 31
Largest monthly default in Sep: 3266.0705
Largest kWh default during LL: 477.3925 - at time: 6535
Fastest increase in kW demand between hours: 122.4374

Generator Worst Case Supply Requirements:
Running for 8 hours: 55.9317 [kW]
Running for 12 hours: 37.2878 [kW]
Running for 16 hours: 27.9658 [kW]
Running for 24 hours: 18.6439 [kW]
```

From these data you can see that in our worst case day, our biomass generator need to run a 30 kW production for 16 hours to the battery, then the battery will supply the load as it's output is higher in kW, a generator matching a 130 kW is way too big from what i can gather. I don't think the 24 hour option is a very practical solution[2]. Given that the generator is started in time for sufficiently charging the battery, the system will not go offline during this scenario. This might be predicted, as a rainy day[3]. Whether we need some more serious margins is something I am willing to discuss, but I think there is reason for not guarding 100% against a possible power-loss, as that makes

[2]If operating at 24 hours the system is more likely to overcharge the battery and produce redundant energy, also there is a matter of operating the system, it is more convenient if an operator can get up at sunrise or earlier and start the system within ordinary working hours

[3]How we can predict insufficient IRR is one of my requests

for some expensive and extensive design, with regards to both installation and operation.

### 2.2 Choice of generator

**Gasifier - Gasoline-run Generator** This is a system that involves creating gas through incomplete combustion of biomass. This allows for a more varied input to the system, less need for a heat-sink, more efficiency, less pollution, and is traditionally better for our scale of generation. This system however requires more attention while being operated, as biomass distribution in the gasifier might become a problem, and I assume more technical attention to monitor heat distribution and process efficiency, thus a purchase also include training for the people involved; this might become expensive. On the other hand, gas can fuel a normal gasoline-run generator which can be fixed or replaced easily, this however might not be relevant given the long life span of the steam-run generators.

**Thermal - Steam Turbine** A steam turbine is a simple construct that require little maintenance if utilized correctly. It does not require extensive training. However there will be need for assembling a well designed boiler, as we need to generate 90 or 95% (i think) dry steam, which implies high pressure and thus a properly well made boiler / pipe system. We also need to get rid of the excess heat, which might get substantial depending on the system. I imagine that for two 15kW generators to produce 30 kW, we will use two boilers for each generator, and one or two furnaces[4]. This system does thus rely more on the craftsmanship during the installation and assembly. The system is also less efficient than the gasifier if I understand it correctly The generator will, when broken, have to be replaced; the estimated lifespan is 10,000 hours of use[5] which amounts to >20 years in the scenario estimated below, (this is the same as the PV-array or battery?)

## 3 Data Required

Based on the simulated scenario drafted above, I believe the following data will deem useful.

### 3.1 Biomass availability

I am somewhat unsure of the efficiency we can expect from a generator, but this does not have to be concluded right now. According to Marthe Wiig Løtveits master thesis the efficiency is at 10%. From what I understand this is not an underestimation [6]. From the above simulation the following summed loss of

[4] No conclusion here yet

[5] ref: Marte W. Løtveit

[6] I have gathered that 30-40% from heat to electricity and maybe 50-70% from biomass to heat energy might be feasible

load was amounted:

```
Needed kWh/month
Jan: 1660.6096  kWh
Feb: 722.9656   kWh
Mar: 704.0263   kWh
Apr: 518.1626   kWh
May: 1537.8698  kWh
Jun: 2534.2517  kWh
Jul: 4398.9501  kWh
Aug: 3867.2454  kWh
Sep: 4616.6515  kWh
Okt: 998.4274   kWh
Nov: 1038.2221  kWh
Dec: 1578.9156  kWh
Total= 24176.2  kWh
```

**Example Amounts Of Monthly Required Biomass** To get a rough understanding of what this implies, I have put together these example amounts, given that efficiency from biomass to energy is at 10%

```
Amount needed monthly

If utilizing: Sawdust
(2.26 kWh/kg\footnote{from master thesis of Marte W. Løtveit})
Jan: 7347.8302  kg
Feb: 3198.9629  kg
Mar: 3115.1606  kg
Apr: 2292.7546  kg
May: 6804.7336  kg
Jun: 11213.5029 kg
Jul: 19464.3809 kg
Aug: 17111.7054 kg
Sep: 20427.6617 kg
Oct: 4417.8205  kg
Nov: 4593.903   kg
Dec: 6986.3523  kg
Total= 106974.7 kg

If utilizing: Maize
(5.10 kWh/kg\footnote{from master thesis of Marte W. Løtveit})
Jan: 3256.0973  kg
Feb: 1417.5797  kg
Mar: 1380.4437  kg
Apr: 1016.005   kg
May: 3015.431   kg
```

```
Jun: 4969.1209  kg
Jul: 8625.3923  kg
Aug: 7582.8342  kg
Sep: 9052.2579  kg
Oct: 1957.7008  kg
Nov: 2035.7296  kg
Dec: 3095.913   kg
Total= 47404.5  kg
```

**We need to know the following:**

1. What kinds of biomass is available, and at what months? Is our estimate feasible?
2. Can the locals tell you about expected burning efficiency of the biomass?
3. What condition will the biomass be in; in different seasons?
4. Is there opportunity to dry possibly wet biomass?
5. What kind of prices can be expected to pay per. tonne/kg?

## 3.2 Weather

As I am faced with alternatives in generation strategies, I need to get some perspective on how the weather works down there. This does not have to be very detailed, but it needs to be fairly accurate, so this might be the most demanding data to acquire since it spans your entire stay. If you look at figure 1 and figure 2 you can see a set of days with alternating LL and sufficient supply of IRR power. I think there is a pretty big difference between the IRR the days where the LL occurs and when the operation runs smoothly, which makes me believe that the days have "one or the other" type of weather". What's useful figuring out is this:

1. Are there "two kinds of weather" (more than enough IRR/far from enough IRR), like the IRR data seem to indicate?
2. Can you predict within the night before if there will be clouds or rain the next day? Are the weather reports reliable?
3. Is the weather shifting or stable throughout the day?

If you could make some structured notices of this during your stay, it would prove indispensable with respect to working out a good generation strategy!

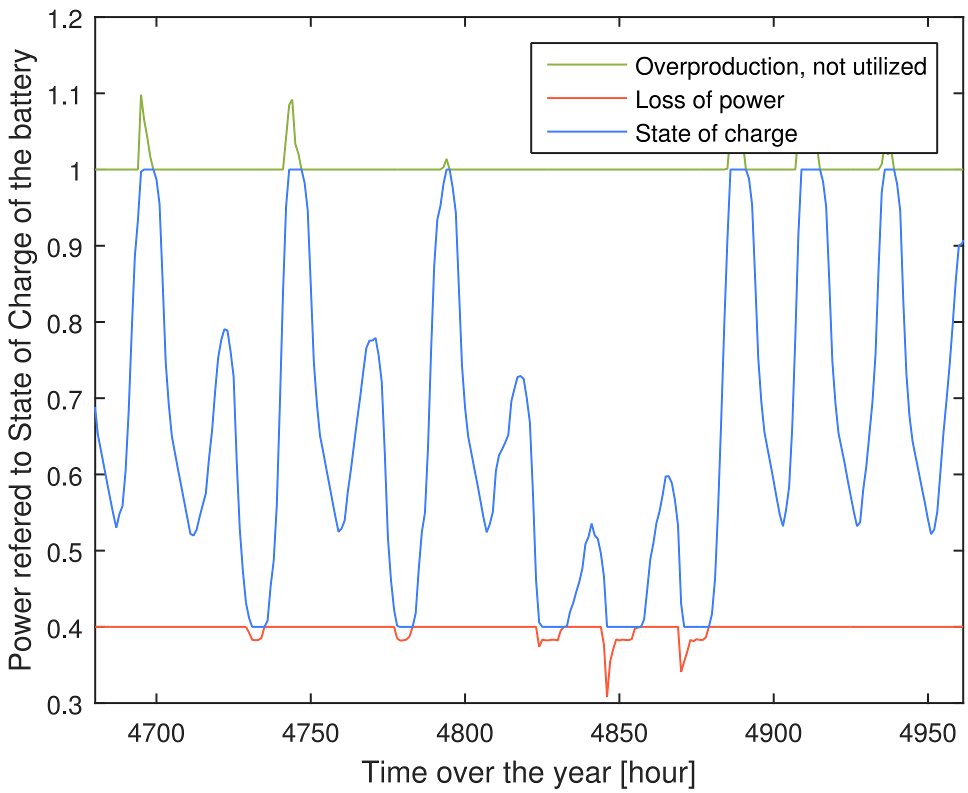


Figure 1: Caption

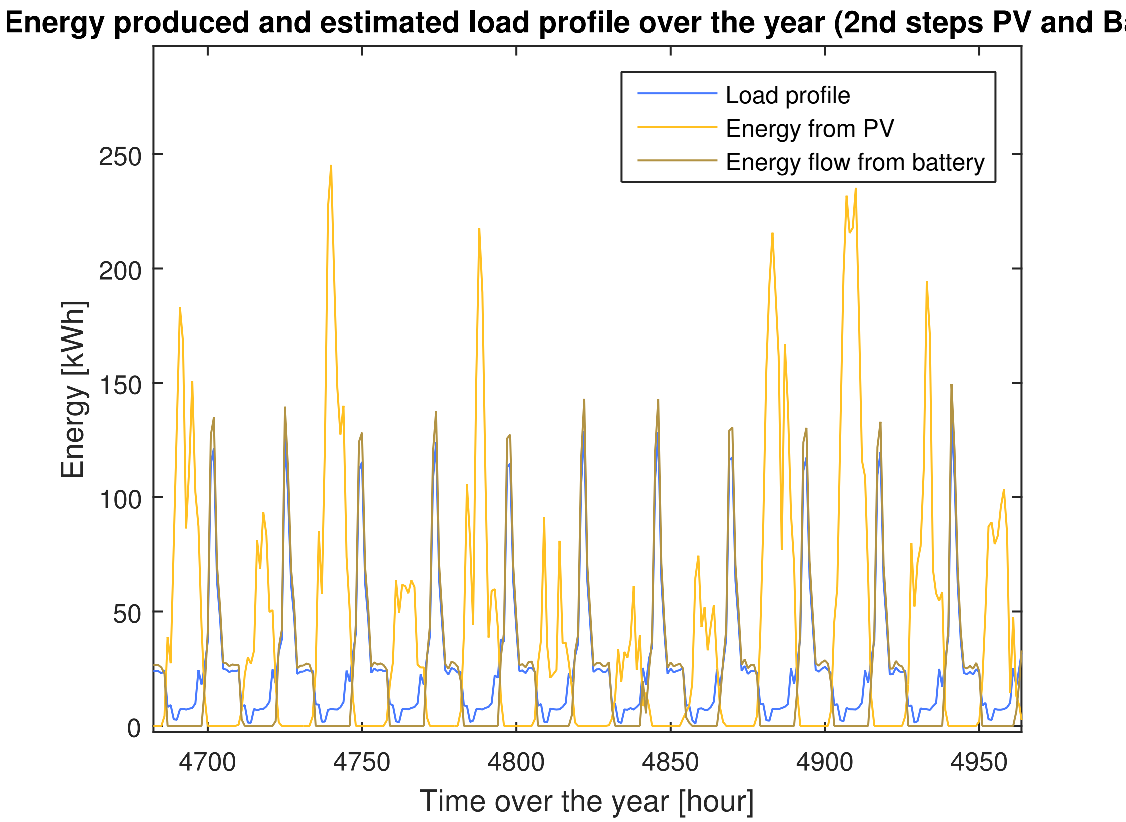


Figure 2: Caption

## 3.3 Staff / People

As you are based in an university I assume that there will be sufficient competent people ensuring handling of the system when it arrives. But it's important to know, however if there will be technical staff available to be given responsibility of learning and training in the use and assembly of the generator? Does it seem like the staff are willing to spare work hours to get the system up-and-running? Is a system like either the steam generator or gasifier welcome on campus as a part of the educational repertoire? Do the administration like the idea? This is just to probe for dedication, since the system will require some logistics if it should be implemented.

## 3.4 Water

The need for water might arise as means of removing excess heat or as a medium in the steam engine.

1. Is there water available throughout the year? Can large quantities be utilized if necessary?

2. How is the composition of the water? Are there any corrosive components? I guess chalk values and pH levels might be relevant here.

## 3.5 Placement

Lastly, the position of the biomass generator might be of some relevance.

1. Is there any way water for the showers/washing can be heated by the heat excess from the generators?

2. Are there placements where noise and exhaust (steam/smoke) is not a problem?

3. Are there placements where the transportation of biomass is unhindered? Will there be possibility of storing the biomass fairly close to the generator?