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81% of villages and 75% of households are yet to be electrified in Cambodia. Currently, ~ 50% of rural households are supplied by Rural Electricity Enterprises (REE=non-government suppliers). Electricity tariffs of licensed REE range between \$0.24/kWh and \$0.88/kWh - about 10-fold more expensive than government-supplied power \$0.09/kWh (residential <50kWh/month) in Phnom Penh. Batteries are generally used for powering lights and TV in un-electrified villages but the unit electricity cost is even more expensive than REE.

The Royal Government of Cambodia is acutely aware of how rural communities are disadvantaged and have set the target of 70% level of household electrification with grid quality electricity by year 2030. The Cambodian Ministry of Industry, Mines and Energy (MIME) will be working to achieve this target via grid extension and mini-grids establishments. It has been proposed that mini-grids establishments will be based on renewable energy because of environmental and economical advantages. Here, we examine the potential of rural electrification in Cambodia based on biomass gasification energy.

•Geological data from the Cambodian Ministry of Public and Transportation, and census data (including estimates of village location, population structure, economical activities) from SEILA and the National Institute of Statistics were used as main information of a GIS framework.

- Appropriate electrification schemes were determined for individual villages according to combined estimates of grid extension potential, electricity demand & ability to pay (>10% TV diffusion), potential to micro hydro power generation and land availability for biomass establishment (grassland and shrubland > 0.02 haHH) (Figure 1).

Annual biomass productivity per unit area; 10 t/ha/year  
Monthly electricity consumption per household; 10 kWh/HH/month  
Woody biomass consumption per unit electricity generation; 1.5 kg/kWh  
 $10 \text{ kWh/HH/month} \times 12 \text{ months} \times 1.5 \text{ kg/kWh} / 10 \text{ t/ha/year} = 0.018 \text{ ha/HH}$

- All villages across Cambodia were assessed according to the above criteria.

- 6,328 villages (56% of un-electrified villages) are appropriate for biomass mini-grid (Table 1). Among those, ~ 3,071 villages in Plain Region (Figure 2) are 'candidate villages for either grid extension or biomass mini-grid' because the area can be electrified by grid extension efficiently.

- We standardized the capital cost (not including distribution system) of diesel generation as \$500/kW and biomass gasification system as \$1,500/kW. Although the capital cost of biomass system is three times higher than a diesel system, the cost for generating unit electricity becomes lower when plant capacity factor exceeds 13% (Figure 3). This is due to the much lower biomass fuel cost (\$0.03/kWh) compared to diesel (\$0.18kWh). The cost of generating biomass power drops to \$0.15/kWh at plant capacity factor 26%.

- Biomass gasification has great potential for rural electrification in Cambodia.

- Agricultural residues such as rice husk (1 million t/year) and old rubber trees (25,000 t/year) are additional potential resources for electricity generation via biomass gasification. However, residues are generally already well utilised as local energy sources and there is insufficient information regarding availability to make estimates at the national level.

- Energy from biomass gasification can be much lower than diesel generation depending on the plant capacity factor (e.g. hours of operation/day). It is therefore critical to create daytime power usage such as drinking water supply, irrigation, commercial uses and small industrial use to obtain preferable tariffs (< \$0.20/kWh) for electrification at the village level.

- There are few estimates of productivity of plantations for biomass in Cambodia. Consequently, there is urgent need for quantification of biomass production and long-term ecological sustainability, as well as species screening and appropriate tree farming technology for farmers.

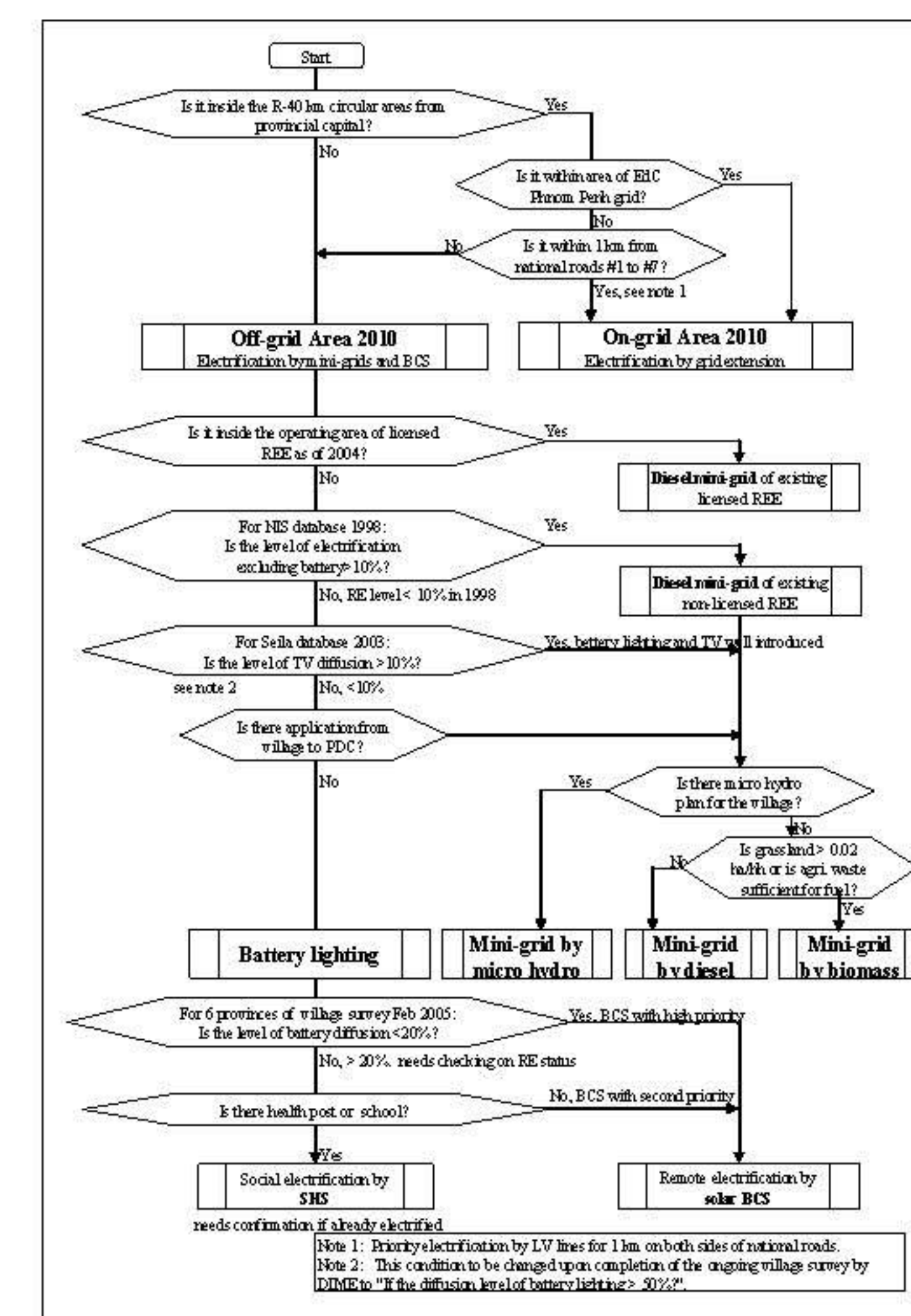
This study is part of a JICA (Japan International Cooperation Agency) funded project 'The Master Plan Study on Rural Electrification by Renewable Energy in The Kingdom of Cambodia'. The study was carried out by MIME and JICA study team collaboratively. All data presented here is derived or modified from the Interim Report (JICA 2005) of the project.



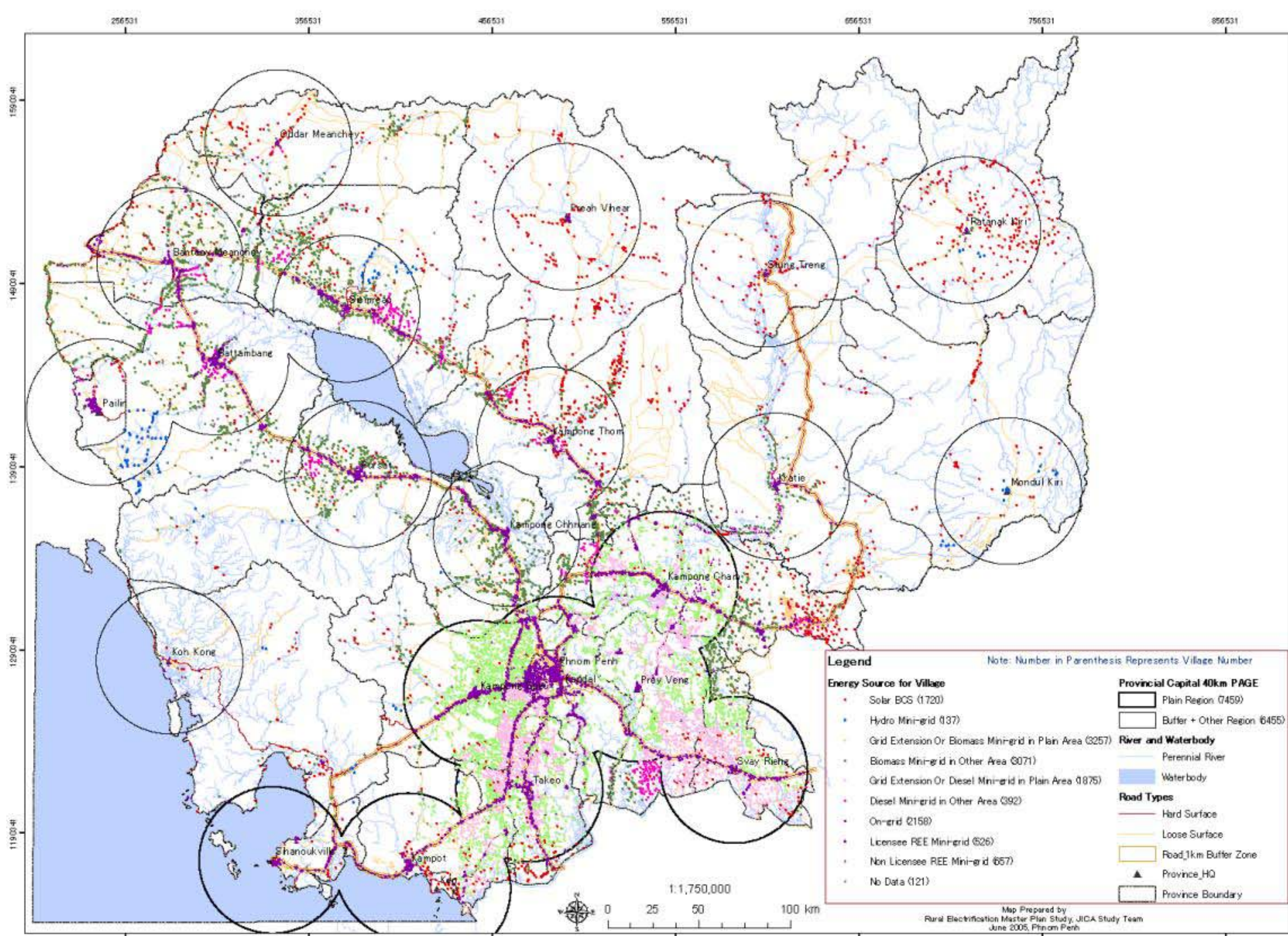
**Figure 4.** There are currently two biomass gasification power plant operating and supplying electricity to total about 500 households. **Far Left;** 9 kW system operated by village energy cooperative. **Middle;** Gasifier invented by local engineer, operated by duel fuel (with diesel). **Near Left;** One year old *Leucaena leucocephala* planted with orange, the branches are used for fuel for power generation.

	Electrification Sources	Number of Villages	Number of Households
Electrified Area	EdC grid	1,405	313,387
	Diesel mini-grid by REE	526	153,350
	Diesel mini-grid by non registered REE	657	156,786
Sub total electrified area		2,588 (19%)	623,523 (25%)
Un-electrified Area	Grid extension	753	208,520
	Solar BCS	1,720	237,570
	Micro hydro	137	18,541
	Biomass gasification	3071	501,634
	Grid extension or biomass gasification	3257	504,397
	Diesel	392	69,390
	Grid extension or Diesel	1,875	294,374
Sub total yet to be electrified		11,205 (81%)	1,834,428 (75%)
Villages with no data		121	n.a.
Total		13,914	2,457,951

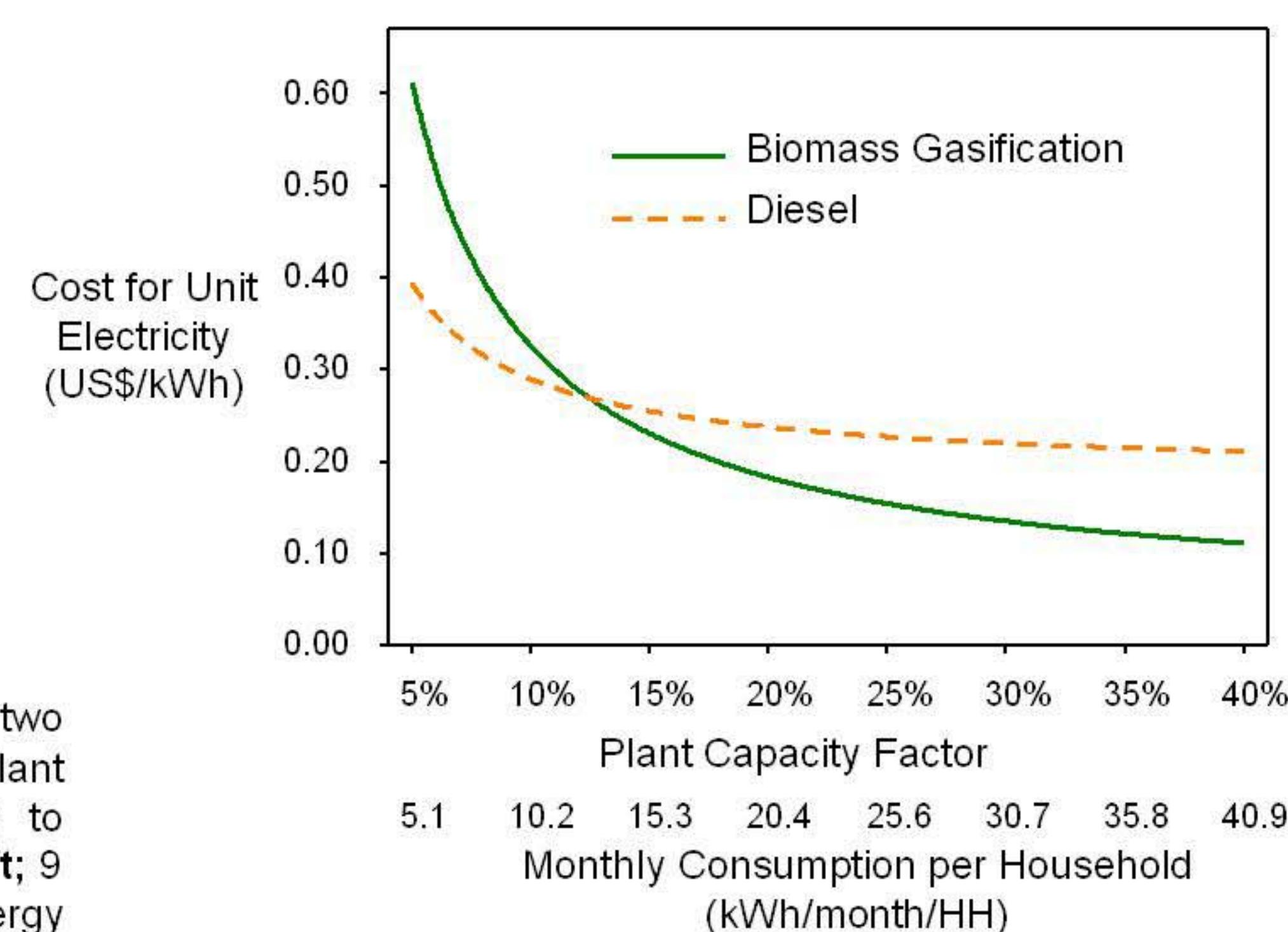
**Table 1.** Number of villages and households for each electrification scheme.



**Figure 1.** Flow chart for sorting villages to appropriate electrification schemes.



**Figure 2.** Villages color-coded by appropriate electrification scheme.



**Figure 3.** Cost comparison for unit electricity generation between biomass gasifier and diesel system.

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