

**ERI-PARI Joint Workshop(3)  
ASEAN Connectivity:  
Power Integration with Myanmar**

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Policy  
Alternatives  
Research  
Institute

# Development of Preliminary Scenarios of Rural Electrification with Cost Estimation of Micro- grid in Myanmar

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# Introduction

- According to our estimation based on JICA's master plan, the target is to electrify for 70% by 2030.
  - 434MW should be provided by micro-grid.
- Not only grid extension but off-grid electrification.

State/Region	Demand in 2012			Demand in 2030		
	MOEP forecast	JICA forecast		MOEP forecast	JICA forecast	
		High case	Low case		High case	Low case
Demand (MW)	1,666	2,075	2,075	19,217	15,477	9,414
Population	50,495,377			66,014,658		
kWh per capita	173	216	216	1,530	1,232	750
Electrification ratio (%)						
Whole country		26		90	80	70
Urban area		45		100	95	90
Rural area		18		86	74	61

# Research Questions and Methodology

- **Research Questions**
  - **How much does it cost to electrify rural area in whole country.**
  - **Explore implications of the national electrification rate target of 70% by 2030**
  
- **Methodology:**
  - **Demand Projection (Mr. Seino presented)**
  - **Cost Estimation**
  - **Development of Preliminary Scenarios**

Source: <http://www.asean.fta.govt.nz/myanmar-overview>

# Framework of this Research

## (1) Demand Projection of Rural Area

### Estimate

- (a) On-grid demand.
- (b) Off-grid demand(micro-grid).  
(Consistent with JICA master plan.)

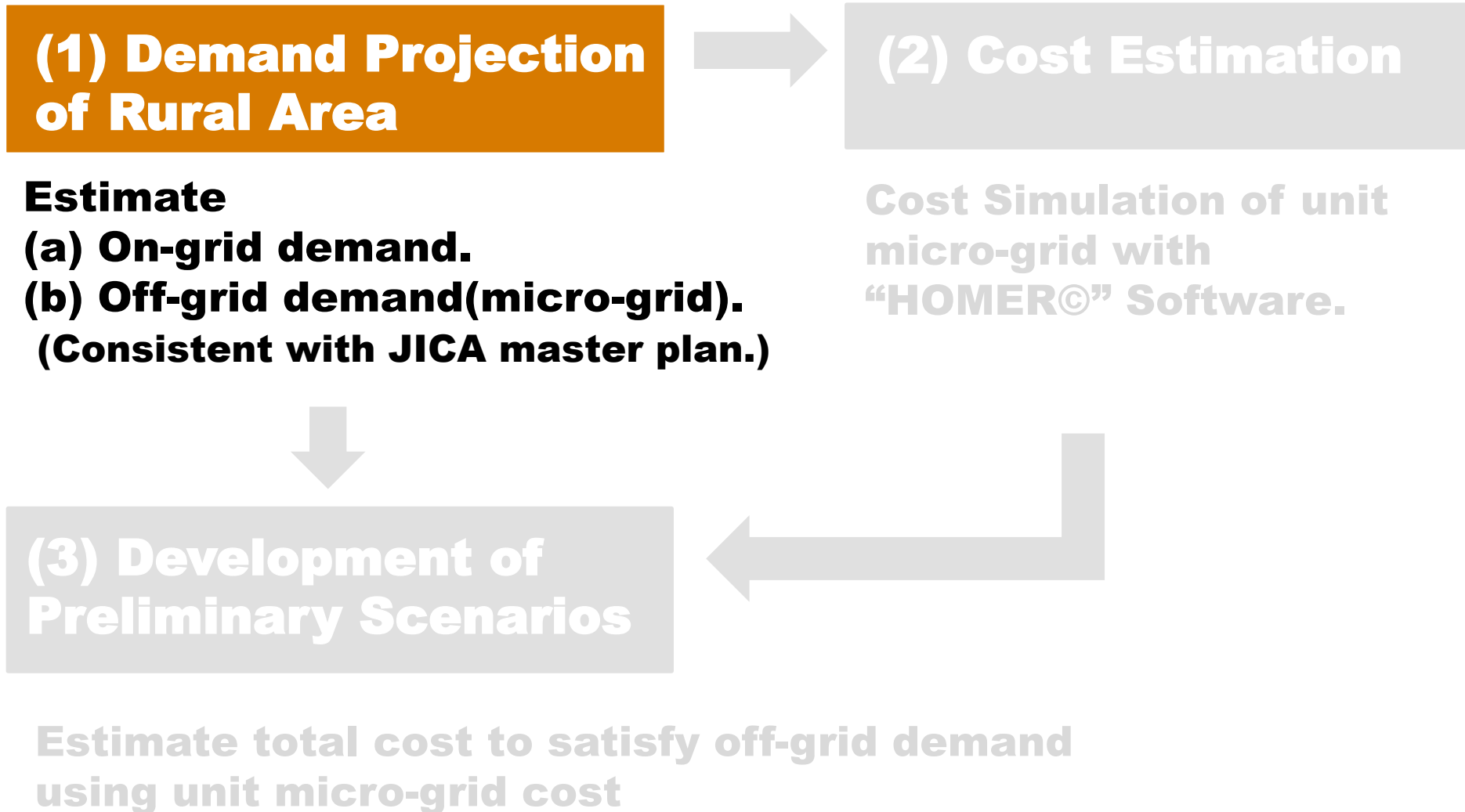
## (2) Cost Estimation

**Cost Simulation of unit  
micro-grid with  
“HOMER©” Software.**

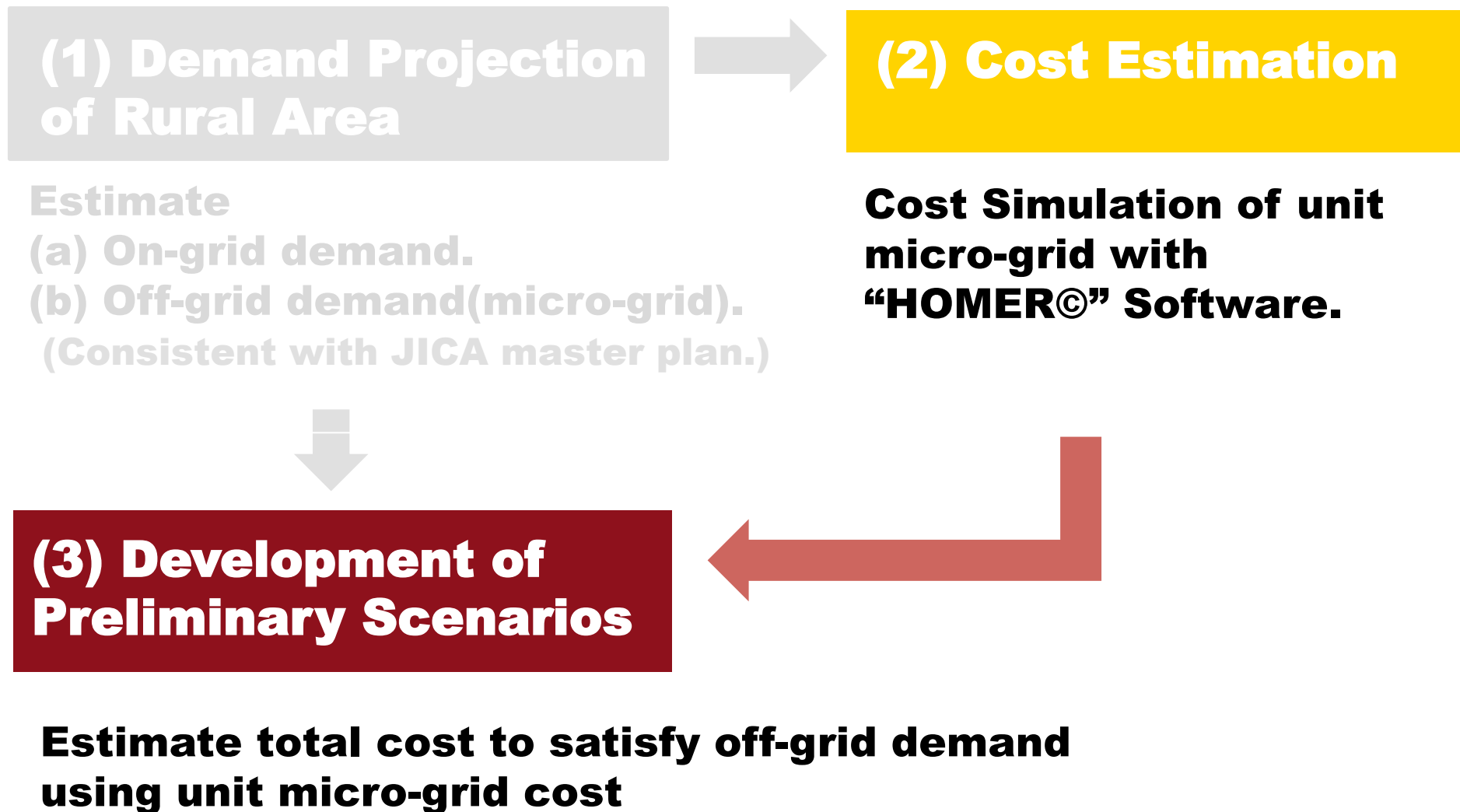
## (3) Development of Preliminary Scenarios

**Estimate total cost to satisfy off-grid demand  
using unit micro-grid cost**

# Framework of this Research



# Framework of this Research



# Equation for calculating minimum NPC

## Total Net Presented Cost(NPC) [USD] required for Rural Electrification by 2030

Model Case	Electrification cost per Unit Micro-grid		The Number of Micro grid	
Case1	*** [USD/microgrid]	×	9,989 [micro grids]	Assumption Low case 70%
Case2	*** [USD/microgrid]	×	1,110 [micro grids]	
Case3	*** [USD/microgrid]	×	2,854 [micro grids]	Middle case 20%
Case4	*** [USD/microgrid]	×	317 [micro grids]	
Case5	*** [USD/microgrid]	×	1,427 [micro grids]	High case 10%
Case6	*** [USD/microgrid]	×	159 [micro grids]	

**=**  $\sum$

# (2) Cost Estimation - Boundary Condition

## 6 Cases

**3 Cases  
(Load Level)**

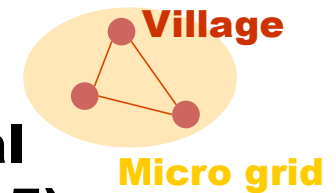
**×**

**2 Cases  
(Environment)**

- **Low Case**
- **Middle Case**
- **High Case**

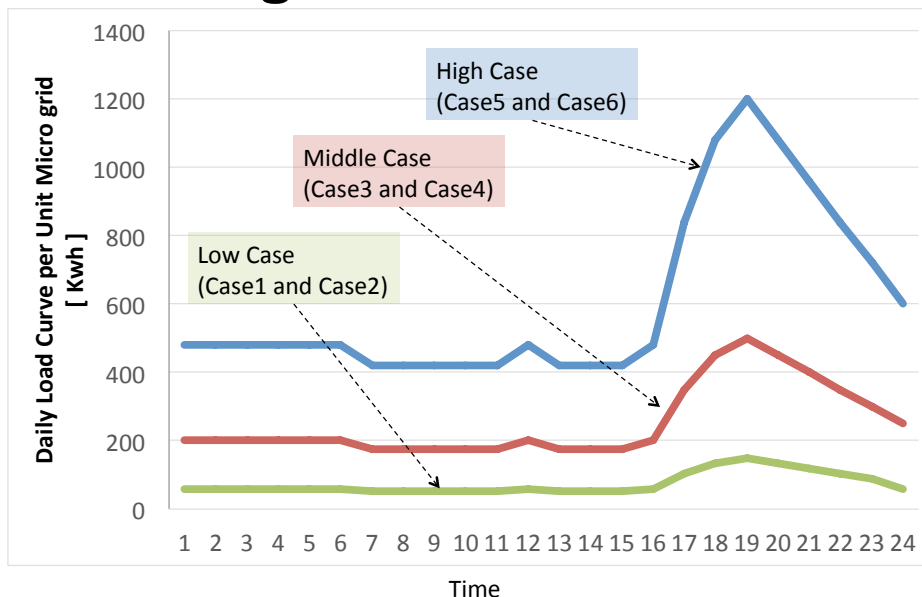
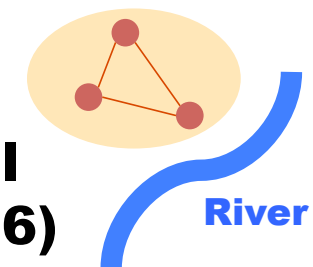
· **Without  
Hydro potential  
(Case 1, 3 and 5)**

90% of whole Micro grids in Myanmar  
(No evidential data)



· **With  
Hydro potential  
(Case 2, 4 and 6)**

10% of whole Micro grids in Myanmar  
(No evidential data)





## (2) Cost Estimation - Boundary Condition

### Components

- **Photovoltaic(PV)**
- **Diesel Generator**
- **Biogas Generator**
- **Battery**
- **Converter**
- **Hydro Generator**

**For All Cases**

**Only for  
Case 2, 4 and 6**

→ **Seek for an optimal (minimum cost) configurations for each micro grid.**

## (2) Cost Estimation - Boundary Condition

### Technical Specification of Composite Power Sources (1)

Characteristics	PV module	Hydro turbine	Diesel Generator
Model	Typical	Mini hydro	Typical
Power	1kWp	151kW	50 kW
Life time	20 years	25 years	20 years
Price	2250 USD/kW	4000 USD/kW	15000 USD/50kW
Replacement	1500 USD/kW	4000 USD/kW	8000 UDS/50kW
Maintenance[/year]	2 USD/kW	80 USD/kw	0.7 USD/hr/50kW
Install Unit	10 kW	1 unit	10 kW

**Reference Source: Author edited refer from Lipu, et al., (2013).**

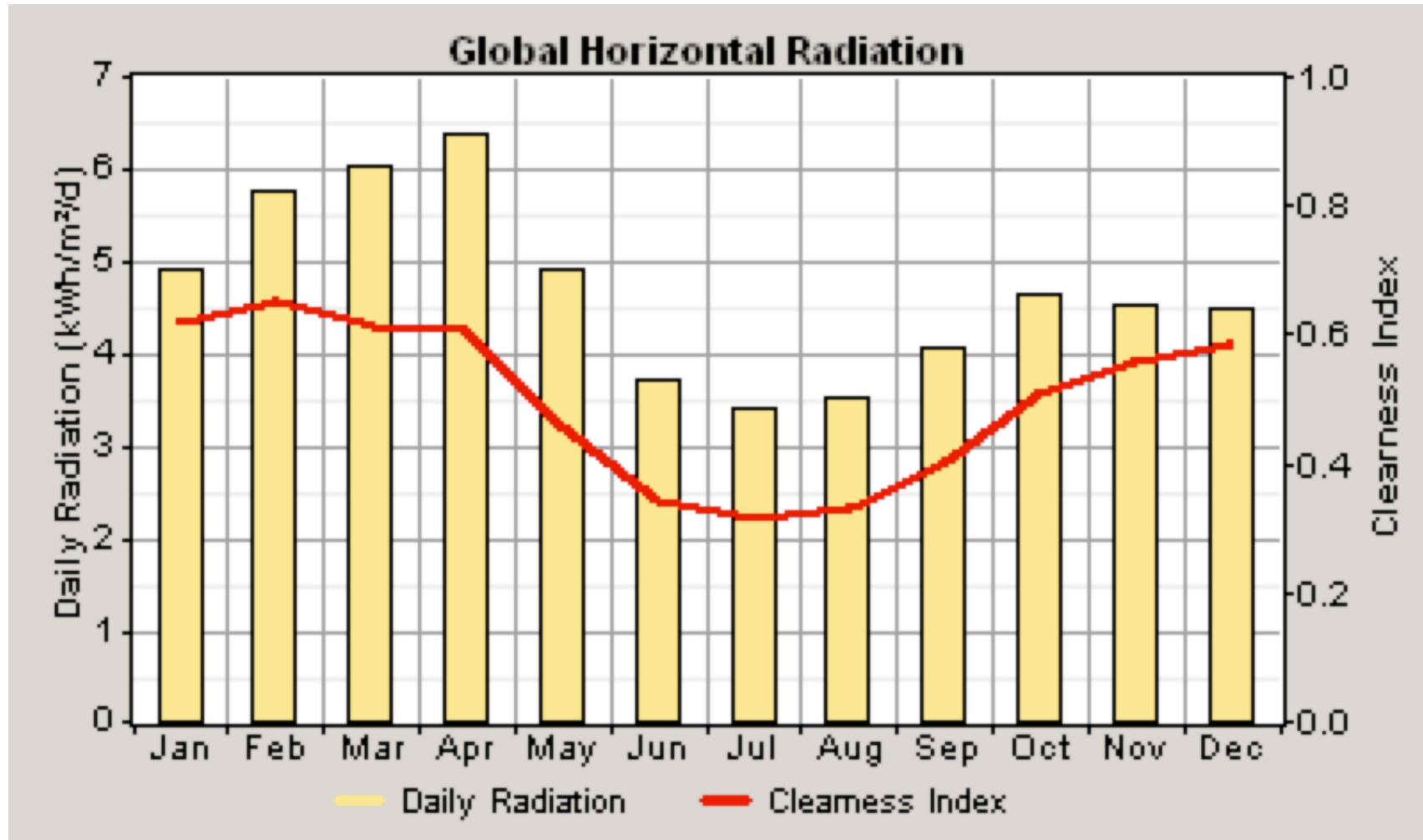
# (2) Cost Estimation - Boundary Condition

## Technical Specification of Composite Power Sources (2)

Characteristics	Biogas Generator	Battery	Converter
Model	RH-3	Trojan T-105	Typical
Power		Nominal voltage 6V Nominal capacity 225 Ah	1kW
Life time		Lifetime throughput 845 kWh	20 years
Price	2300 USD/6kW	225 USD/battery	400 USD/kW
Replacement	1700 USD/6kW	200 USD/battery	250 USD/kW
Maintenance[/year]	0.01 USD/10kW	1 USD/battery	1 USD/kW
Install Unit	10 kW	10 unit	10 kW

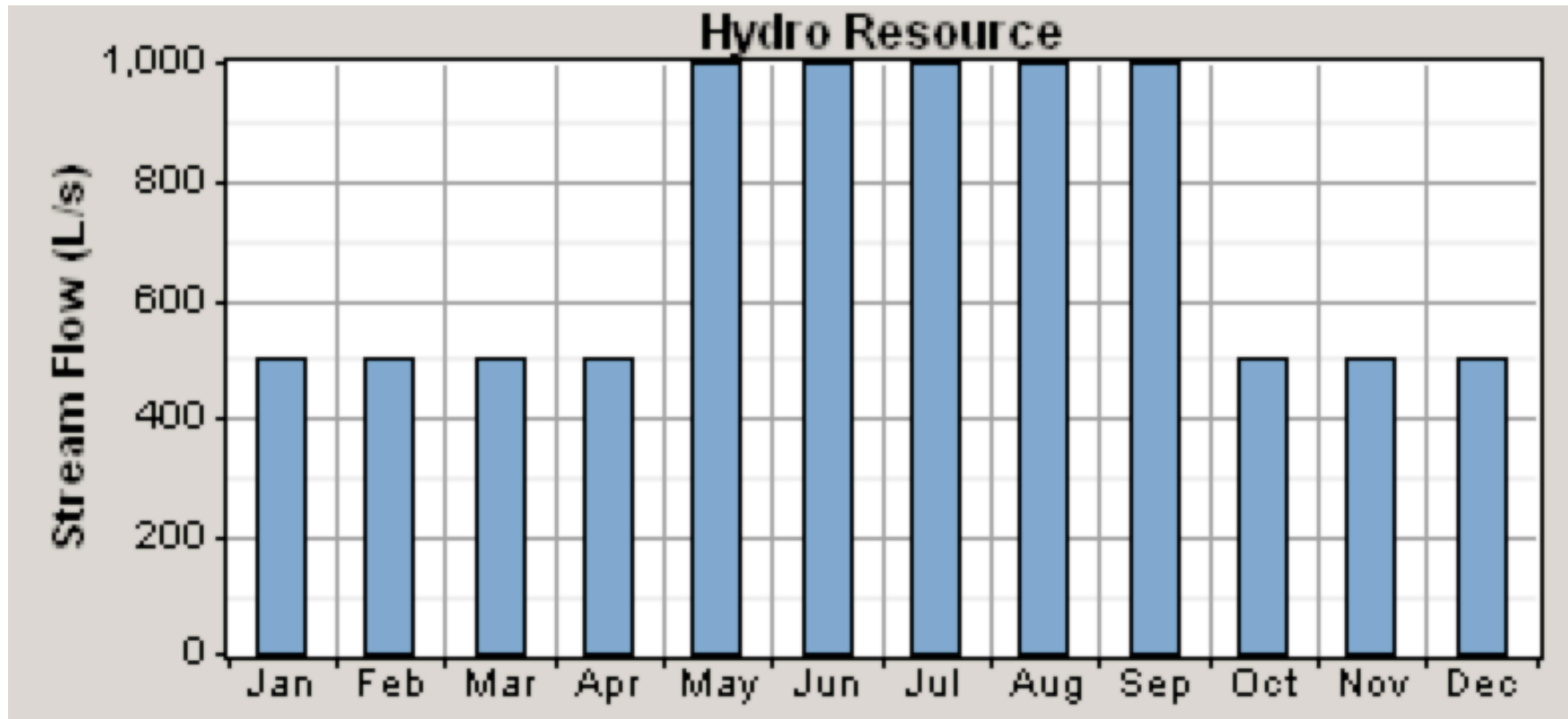
**Reference Source: Author edited refer from Lipu, et al., (2013).**

# Amount of Sunlight



Source: Tiet et al. (2008)

# Boundary Condition - Hydro Power Potential



Source: The Institute of Electrical Engineers of Japan. (2001).

# Biogas potential

No.	State/Division	Population	Paddy Production		Rice Husk	Potential	Potential
		in 1997	in 1996-1997	per capita	Production	Energy	Power
		1,000	1,000 ton	kg	1,000 ton	GWh	kW
		1	2	3	4	5	6
1	Kachin State	1,202	315	262	63	5	2,280
2	Kayah State	246	76	310	15	1	550
3	Kayin State	1,403	454	324	91	7	3,330
4	Chin State	458	66	144	13	1	500
5	Sagaing Division	5,180	1,564	302	313	25	11,420
6	Tanintharyi Division	1,269	231	182	46	4	1,690
7	Bago Division	4,848	2,930	604	586	47	21,420
8	Magway Division	4,301	576	134	115	9	4,200
9	Mandalay Division	6,188	913	148	183	15	6,670
10	Mon State	2,337	889	380	178	14	6,480
11	Rakhine State	2,610	925	354	185	15	6,760
12	Yangon Division	5,295	1,623	306	325	26	11,870
13	Shan State	4,629	942	203	188	15	6,890
14	Ayeyarwady Division	6,436	5,894	916	1,179	94	43,060
	Union Total	46,402	17,397	375	3,480	278	127,120

**The daily production: 123 kg / day**

Source: The Institute of Electrical Engineers of Japan (2001)

# (2) Cost Estimation – Result 1

		PV (kW)	Hydro (kW)	Dies (kW)	Biog (kW)	T-105	Converter (kW)
Case1	Low Demand Case	20		10	10	30	10
Case2		20		10	10	30	10
Case3	Middle Demand Cases	50		40	20	60	30
Case4				151		10	10
Case5	High Demand Cases	130		110	40	50	60
Case6				151	30	10	40

**Cont.**

		Total NPC(\$)
Case1	Low Demand Case	212,258
Case2		212,258
Case3	Middle Demand Cases	766,061
Case4		640,603
Case5	High Demand Cases	1,943,341
Case6		736,526

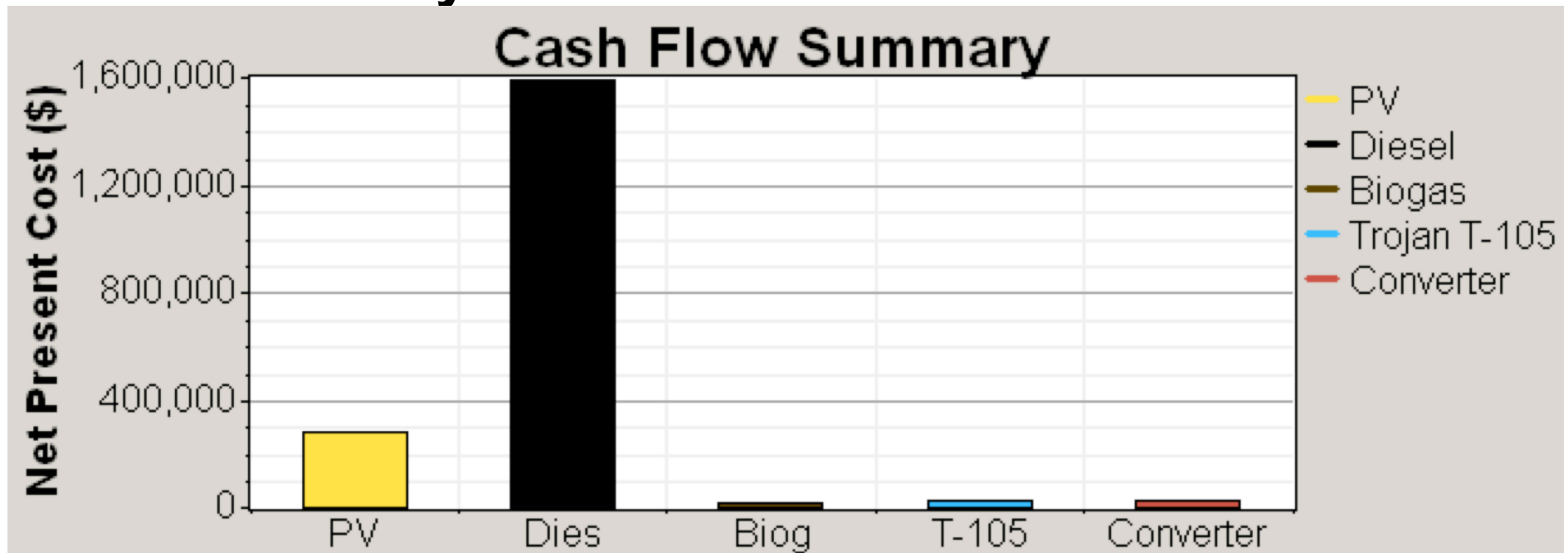
# (2) Cost Estimation - Result 1

## Example) Case 5(High Demand)

		PV (kW)	Hydro (kW)	Dies (kW)	Biog (kW)	T-105	Converter (kW)
Case5	High Demand Cases	130		110	40	50	60
Case6				151	30	10	40

**Excess Electricity: 7%**

**Cost of Electricity: 0.482USD/kWh**





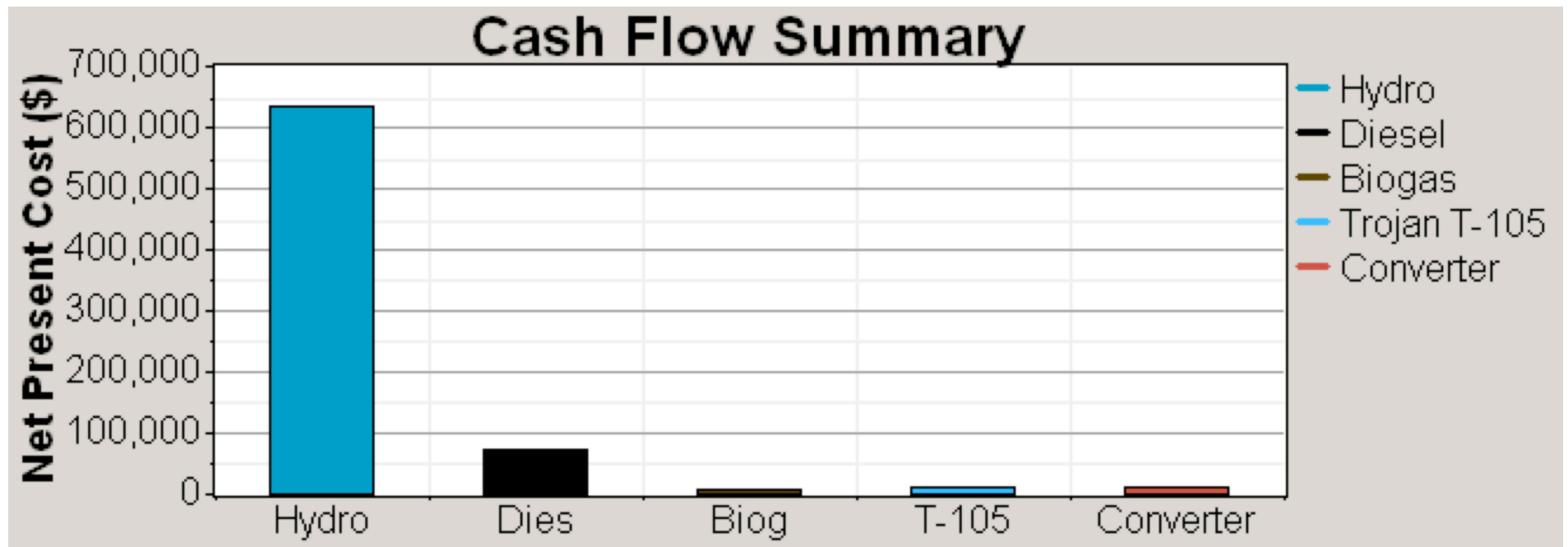
# (2) Cost Estimation - Result 1

## Example) Case 6 (High Demand with Hydro power)

		PV (kW)	Hydro (kW)	Dies (kW)	Biog (kW)	T-105	Converter (kW)
Case5	High Demand Cases	130		110	40	50	60
Case6			151	30	10	40	30

**Excess Electricity: 45%**

**Cost of Electricity: 0.183USD/kWh**



# (3) Scenario Preparation

## Unit cost for micro-grid installation in off-grid electrification

Case	Component of micro-grid	Unit cost per micro-grid (US\$/micro-grid) Total	Micro-grid number (Electrified villages)	Electrification cost (MUS\$) Total
1	PV+Dies+Biog+Bat+Con	212,258	9,989	2,120
2	PV+Dies+Biog+Bat+Con	212,258	1,110	236
3	PV+Dies+Biog+Bat+Con	766,061	2,854	2,187
4	Hydro+Bat +Con	640,603	317	203
5	PV+Dies+Biog+Bat+Con	1,943,341	1,427	2,773
6	Hydro+Dies+ Biog+Bat+Con	736,526	159	117
Total			15,856	7,636
US\$ per micro-grid			—	481,584
US\$ per kW			—	14,827

**Total Electrification (Rural) Cost: 7,636 M USD**

**Caveats: the results depend on: hydro availability, technology costs (e.g., PV), rather large demand, coarse data resolution**

# Summary

- **(1) Demand Projection of Rural Area**
  - **To achieve 70% electrification, 434MW should be provided by micro-grid.**
  
- **(2) Cost Estimation**
  - **Unit micro grid cost is estimated at 0.2M USD - 2M USD depending on configurations.**
  
- **(3) Development of Preliminary Scenarios**
  - **We tentatively estimated total cost(inc. capital and operation costs ) at 7.6 Billion USD for rural electrification for approx.16,000 micro-grids.**

# Future work

- **This result is tentative.**
- **Improve population data.**
- **Improve data for hydro power potential.**
- **Consider SHS(Solar Home System) in addition to micro-grid.**
- **Produce multiple scenarios that take priorities into account.**

# Thank you for your attention.