Multi-Criteria Analysis on Renewable and Non-Renewable Technologies for Electricity Generation in Myanmar

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1. Introduction

- Rich in Natural Resources (Renewables / Non-Renewables / Perpetual)
- Energy Resources (Hydropower / Natural Gas / Solar / Wind / Coal)

1. Introduction

- Rich in Natural Resources (Renewables / Non-Renewables / Perpetual)
- Energy Resources (Hydropower / Natural Gas / Solar / Wind / Coal)

Potential – 108 GW

(World Bank, 1995)

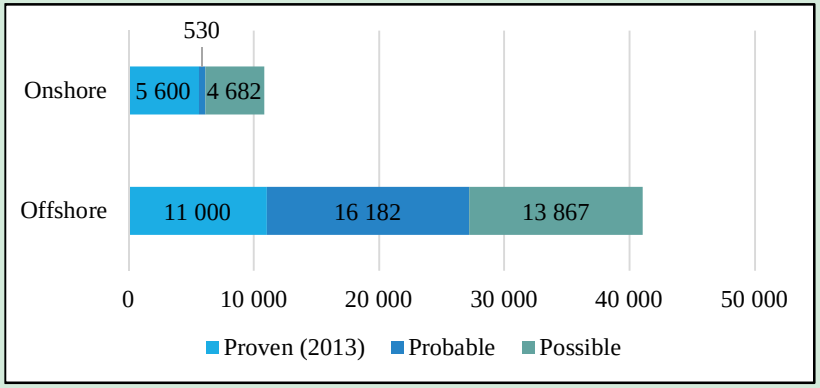
Developed – 3.23 GW

(Kyaw, 2017)

1. Introduction

- Rich in Natural Resources (Renewables / Non-Renewables / Perpetual)
- Energy Resources (Hydropower / Natural Gas / Solar / Wind / Coal)

Gas Potential (BCF)



Ministry of Energy (2013)

1. Introduction

- Rich in Natural Resources (Renewables / Non-Renewables / Perpetual)
- Energy Resources (Hydropower / Natural Gas / Solar / Wind / Coal)

40 TWh per year

A. Ener & Y. Deve (2015)

1. Introduction

- Rich in Natural Resources (Renewables / Non-Renewables / Perpetual)
- Energy Resources (Hydropower / Natural Gas / Solar / Wind / Coal)

365.1 TWh per year

NEDO, 1997

1. Introduction

- Rich in Natural Resources (Renewables / Non-Renewables / Perpetual)
- Energy Resources (Hydropower / Natural Gas / Solar / Wind / Coal)

540 million tons (Ministry of Mine, 2013)

1. Introduction

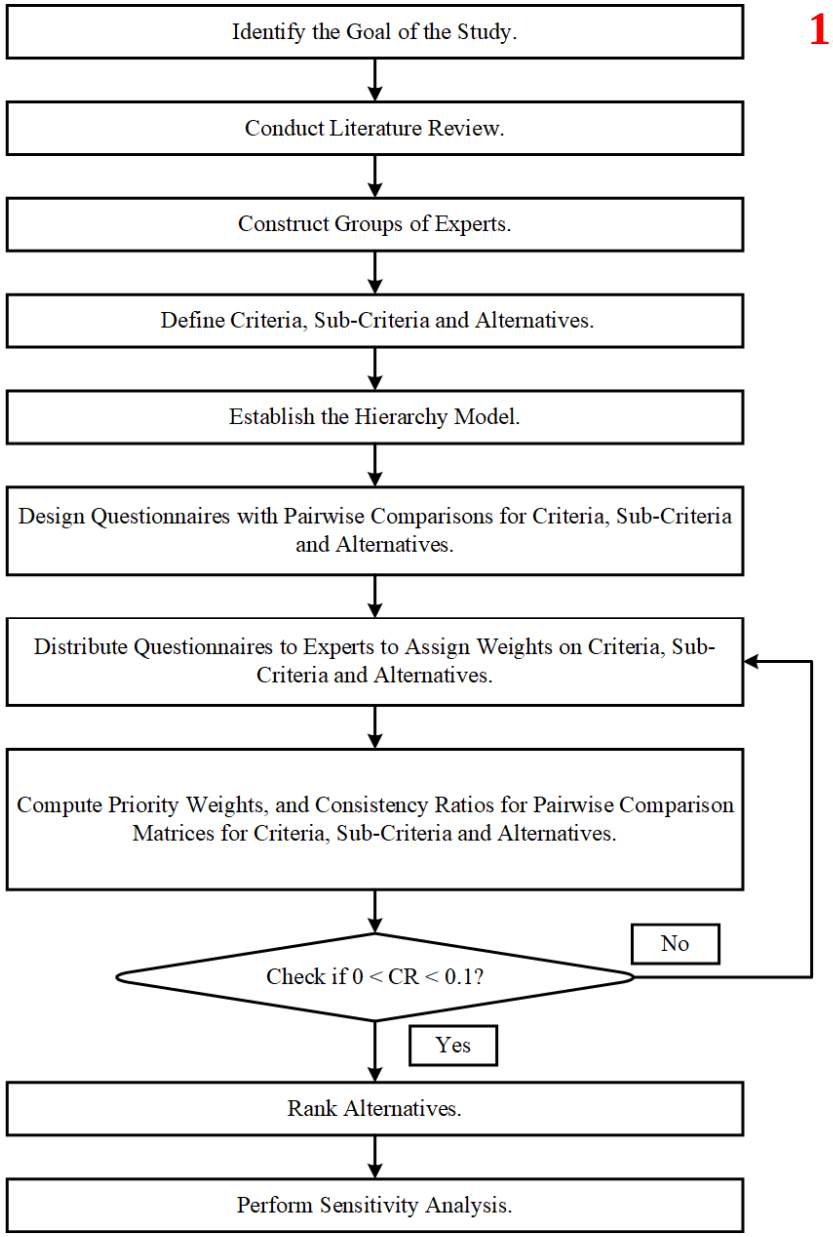
- ❖ Rich in Natural Resources (Renewables / Non-Renewables / Perpetual)
- ❖ Energy Resources (Hydropower / Natural Gas / Solar / Wind / Coal)
- ❖ Current Situations of Electricity Access and Consumption
  - Access to Electricity – 4.289 million households out of 10.877 (38.4%) (Khaing, 2018)
  - Lowest access to grid-connected electricity among South East Asian countries (IFC, 2017)
  - Consumption of Electricity – lowest per capita electricity consumption among South East Asian countries (Nam, Cham, and Halili (2015))
- ❖ Drivers for Electricity Demand
  - University Access to Electricity by 2030 (Khaing, 2018)
  - Industrial Development

1. Introduction

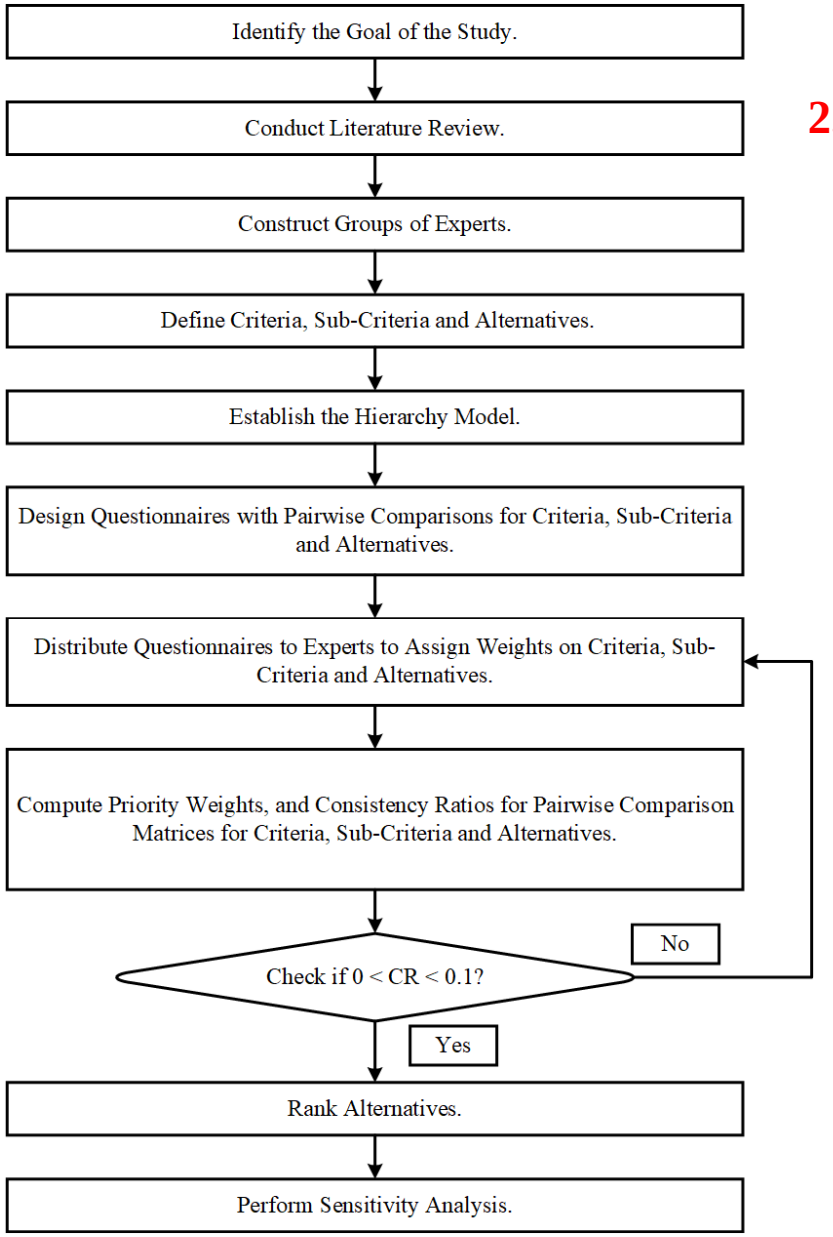
Research Purpose: To choose Renewable and Non-Renewable Generation Technologies for electricity generation in Myanmar

Research Questions:
1. Which criteria should be used?
2. Which criteria and sub-criteria should be paid more attention?
3. Which generation technologies are more preferable?

2. Methodology Framework and Research Method

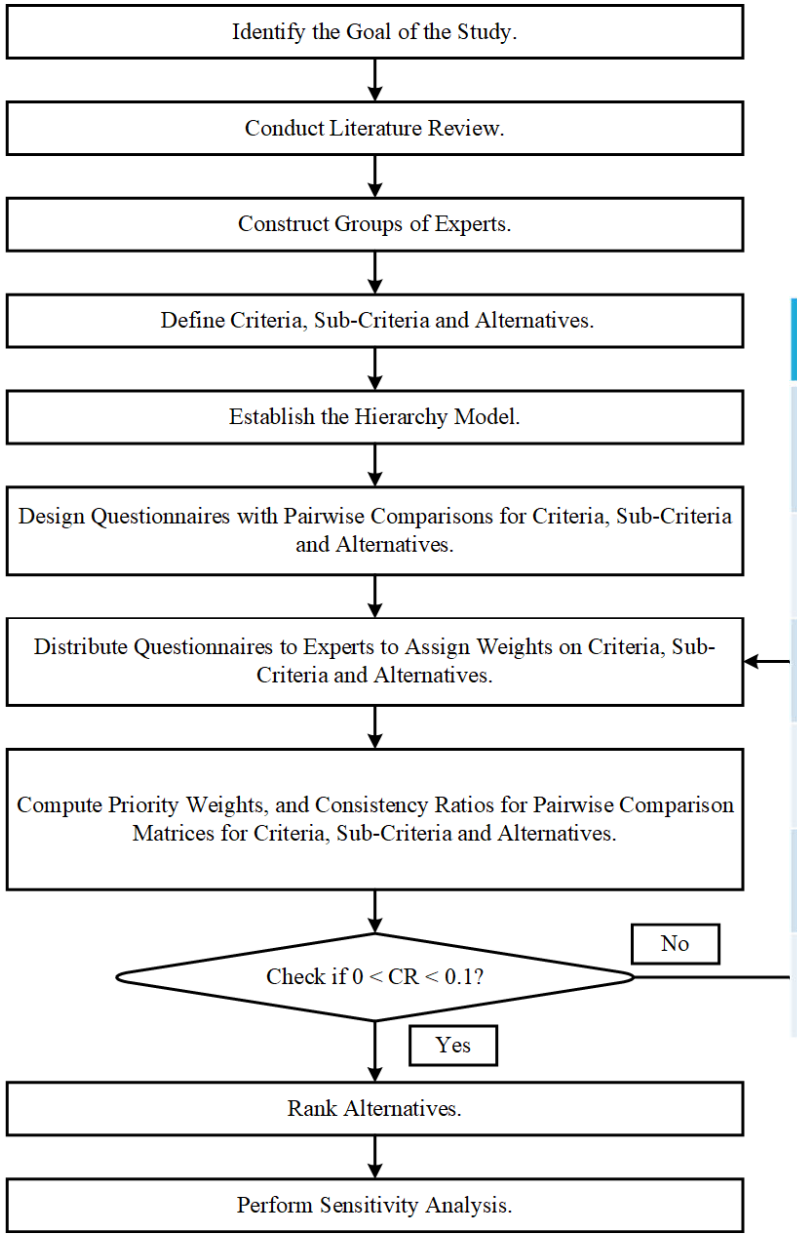


1. Goal - To choose Renewable and Non-Renewable Generation Technologies for electricity generation in Myanmar



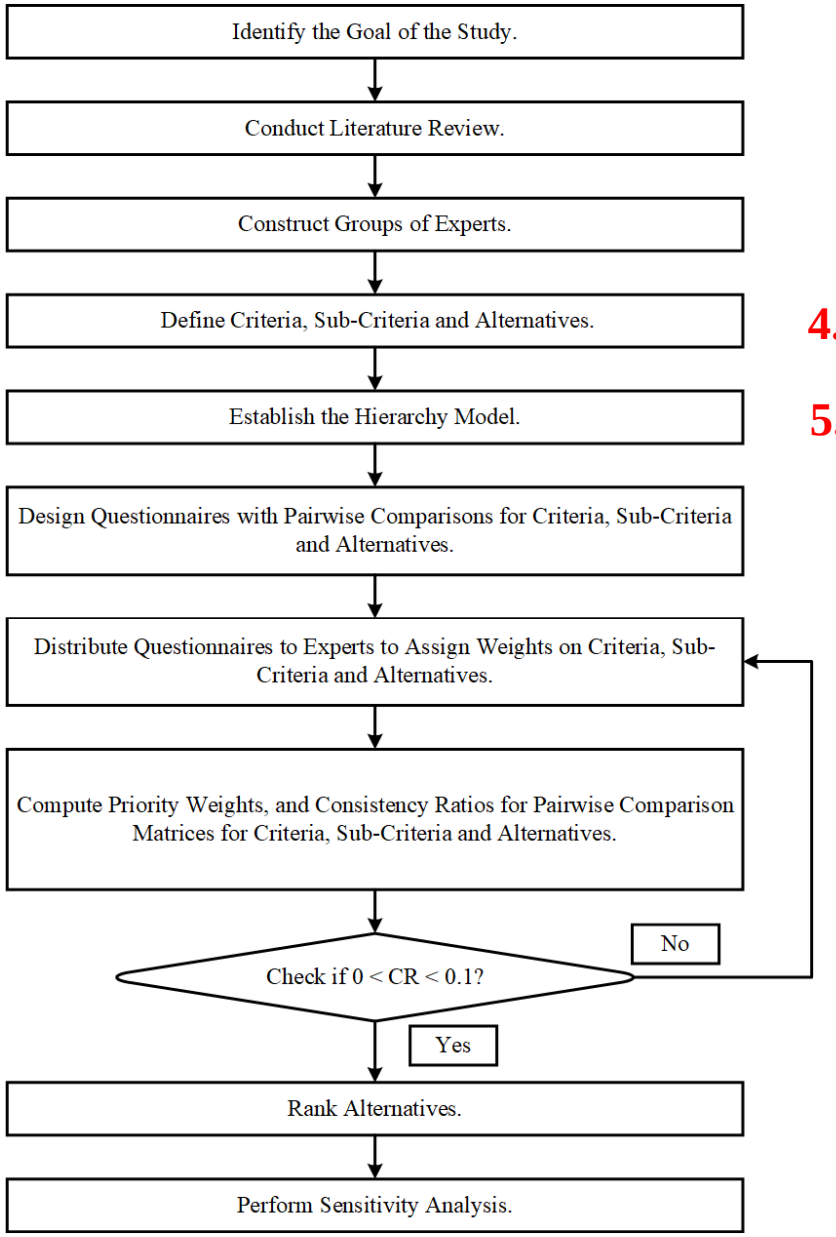
2. Literature Review (Keywords, Similar Situations, 90 papers)

Analytical Hierarchy Method was found to be commonly used and suitable for this study.



3. Construct Expert Groups

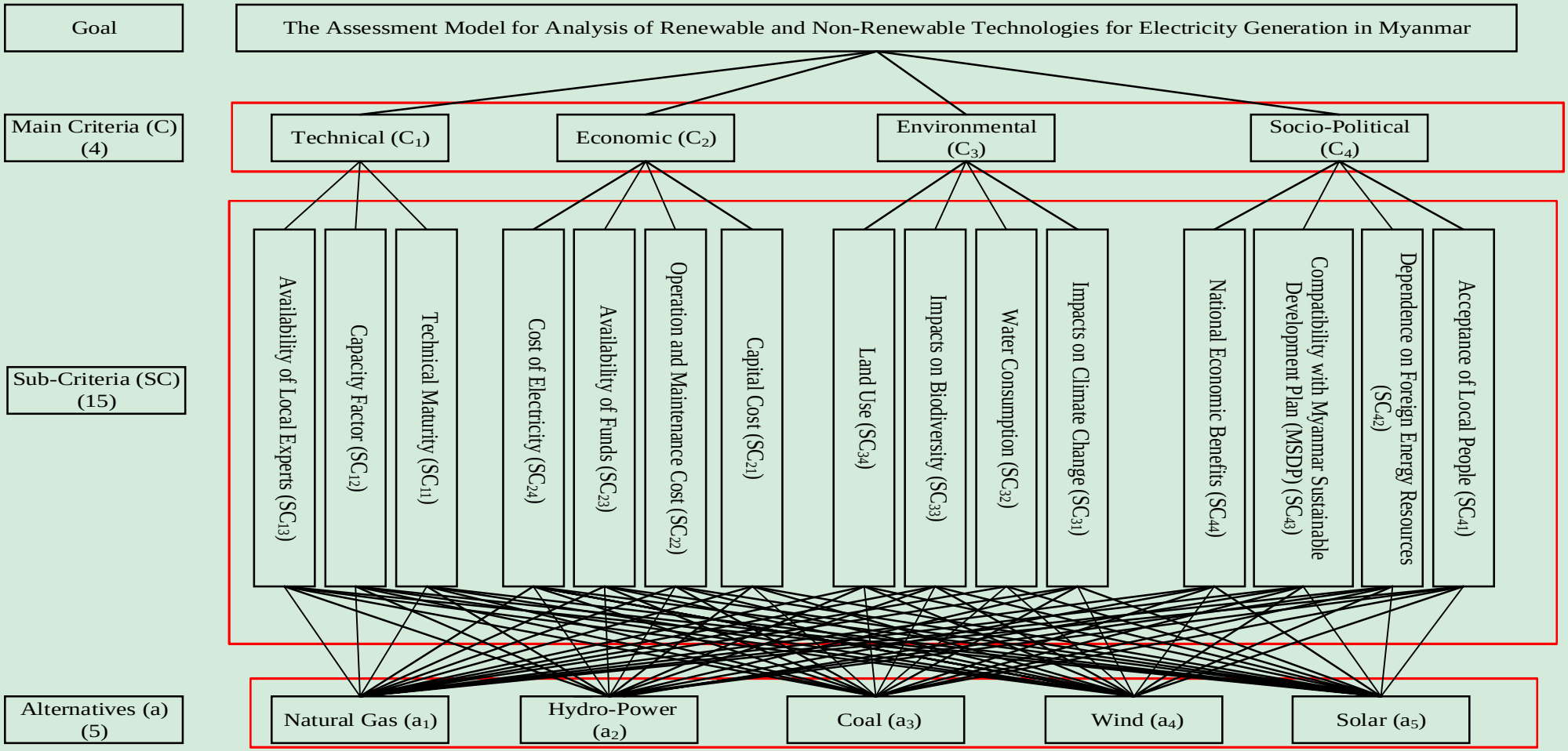
No.	Organization	No. of Experts
1.	Ministry of Natural Resources and Environmental Conservation	7
2.	Ministry of Electricity and Energy	7
3.	Non-Governmental Organizations	7
4.	Private Company	5
5.	Universities	4
	Total	**30**

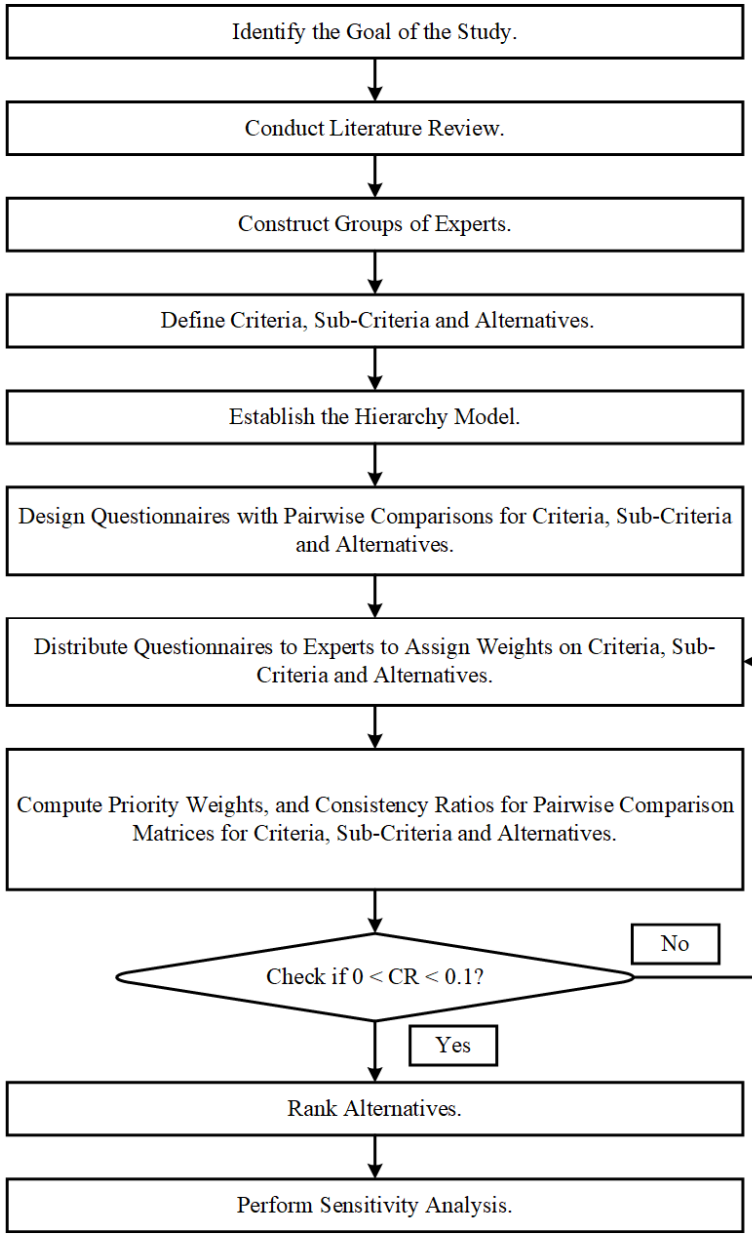


4. Define Criteria, Sub-Criteria and Alternatives (LR and EC)

5. Establish the Hierarchy Model.

Construct AHP Flowchart





6. Design Questionnaires. (3 parts)

Section B : Main Criteria and Sub-Criteria

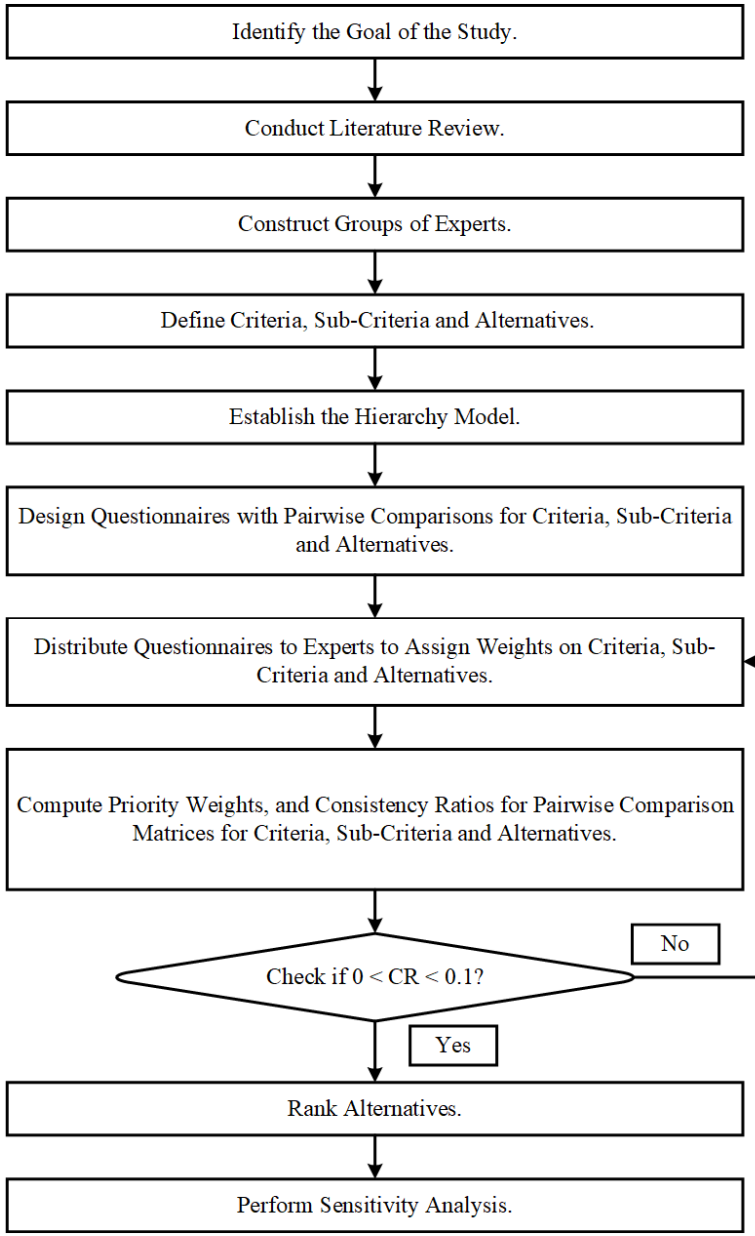
1) Please kindly divide 100 points between each of the following pairings taking into account **Electricity Generation in Myanmar.**

Technical			Economic
Technical			Environmental
Technical			Socio-Political
Economic			Environmental
Economic			Socio-Political
Environmental			Socio-Political

Section C : Alternatives

1) Please kindly divide 100 points between each of the following pairings taking into account alternatives with higher **Technical Maturity.**

Natural Gas			Hydropower
Natural Gas			Coal
Natural Gas			Wind
Natural Gas			Solar
Hydropower			Coal
Hydropower			Wind
Hydropower			Solar
Coal			Wind
Coal			Solar
Wind			Solar



Survey Instructions:

- Please kindly divide 100 points between each pair depending on your preference.
- In dividing 100 points, the choice of your number can vary from 1 to 99, which means that it should not be 0 or 100.

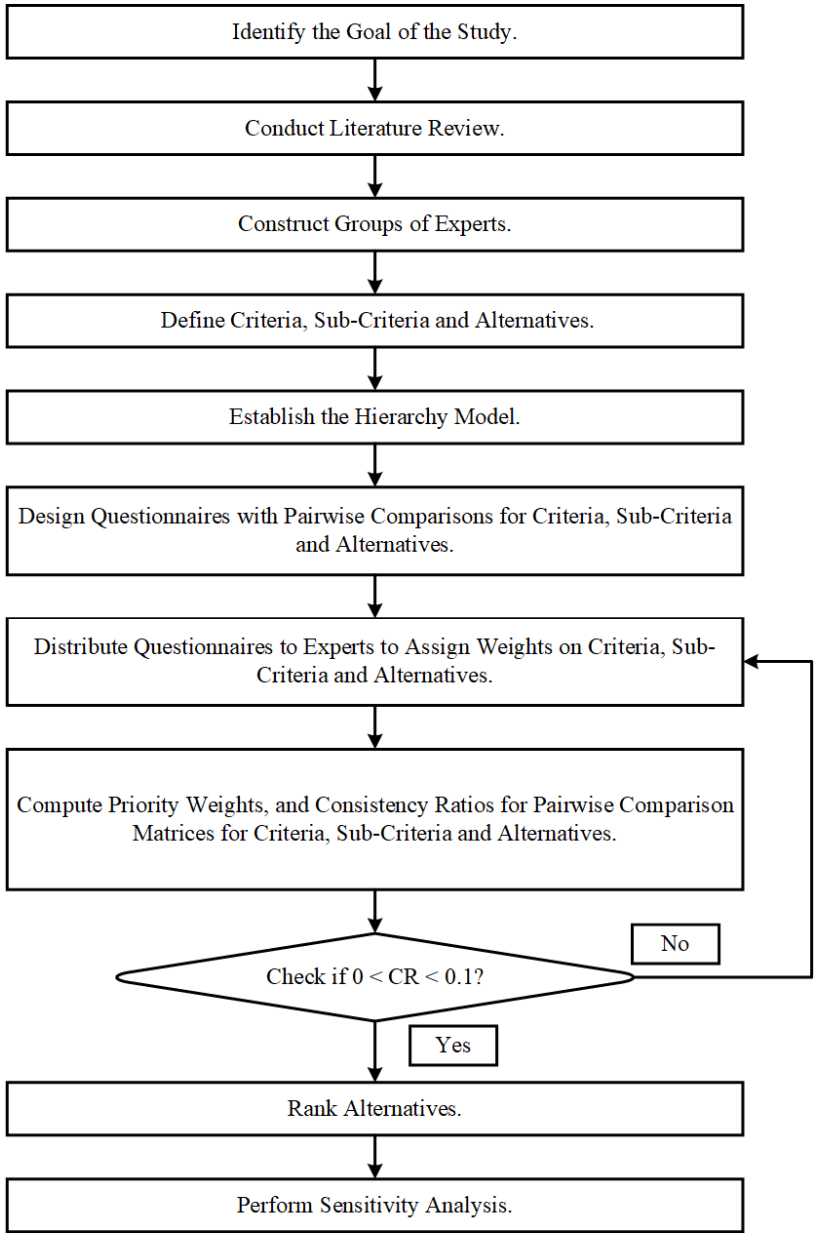
If you have equal preferences for two options, pairwise comparison would be 50:50.

Example:

Please kindly divide 100 points between the following pairing of cities; Yangon and Nay Pyi Taw, taking into account **Your Preference.**

(Let's say you slightly prefer "Yangon" to "Nay Pyi Taw". Then, your choice might be as follows.)

Yangon	60	40	*Nay Pyi Taw*



7. Distribute Questionnaires.

8. Calculate Expert's Choices and their consistency.

9. Rank Priorities.

10. Perform Sensitivity Analysis.

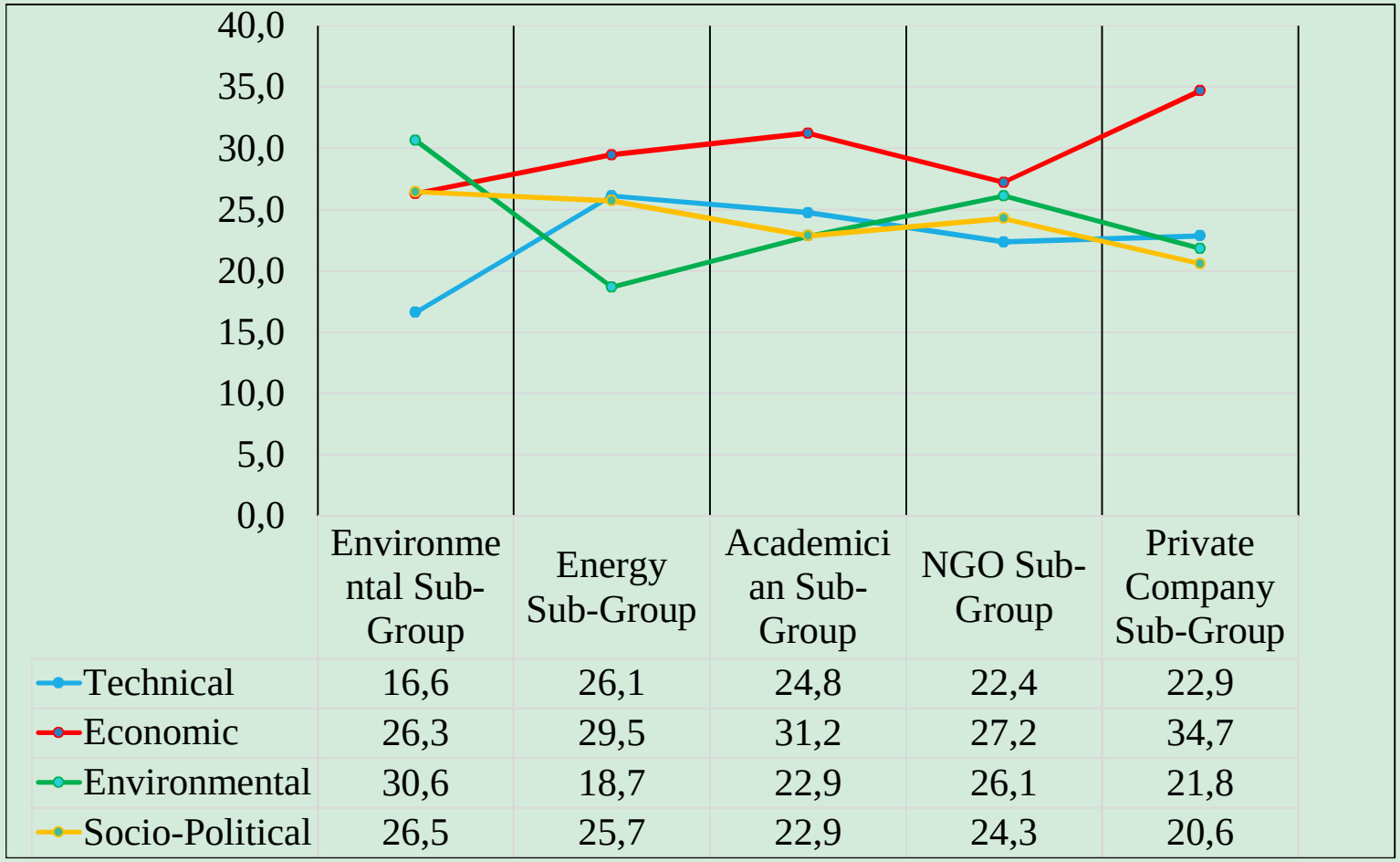
3. Results and Discussion

Analysis of Section A

Organization	Frequency	Percent
Ministry of Natural Resources and Environmental Conservation	7	23.3
Ministry of Electricity and Energy	7	23.3
Non-Governmental Organizations	7	23.3
Private Company	5	16.7
Universities	4	13.3
Total	**30**	**100.0**

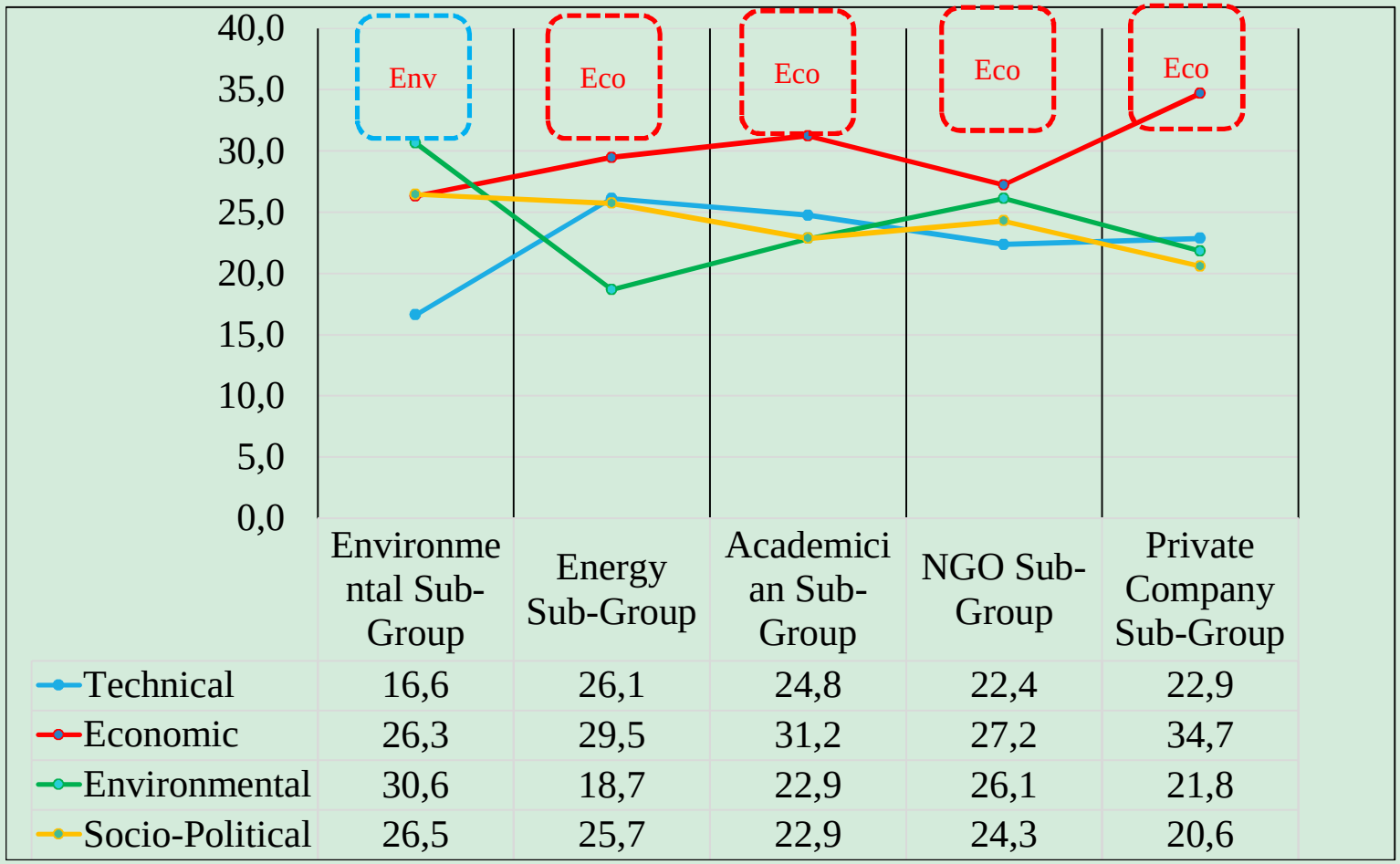
Experience of Experts	Frequency	Percent
More than 20 years	14	46.7
10-20 years	11	36.7
1-9 years	5	16.7
Total	**30**	**100.0**

Evaluation of Main Criteria by Sub-Group



	Environmental Sub-Group	Energy Sub-Group	Academician Sub-Group	NGO Sub-Group	Private Company Sub-Group
Technical	16,6	26,1	24,8	22,4	22,9
Economic	26,3	29,5	31,2	27,2	34,7
Environmental	30,6	18,7	22,9	26,1	21,8
Socio-Political	26,5	25,7	22,9	24,3	20,6

Evaluation of Main Criteria by Sub-Group



	Environmental Sub-Group	Energy Sub-Group	Academician Sub-Group	NGO Sub-Group	Private Company Sub-Group
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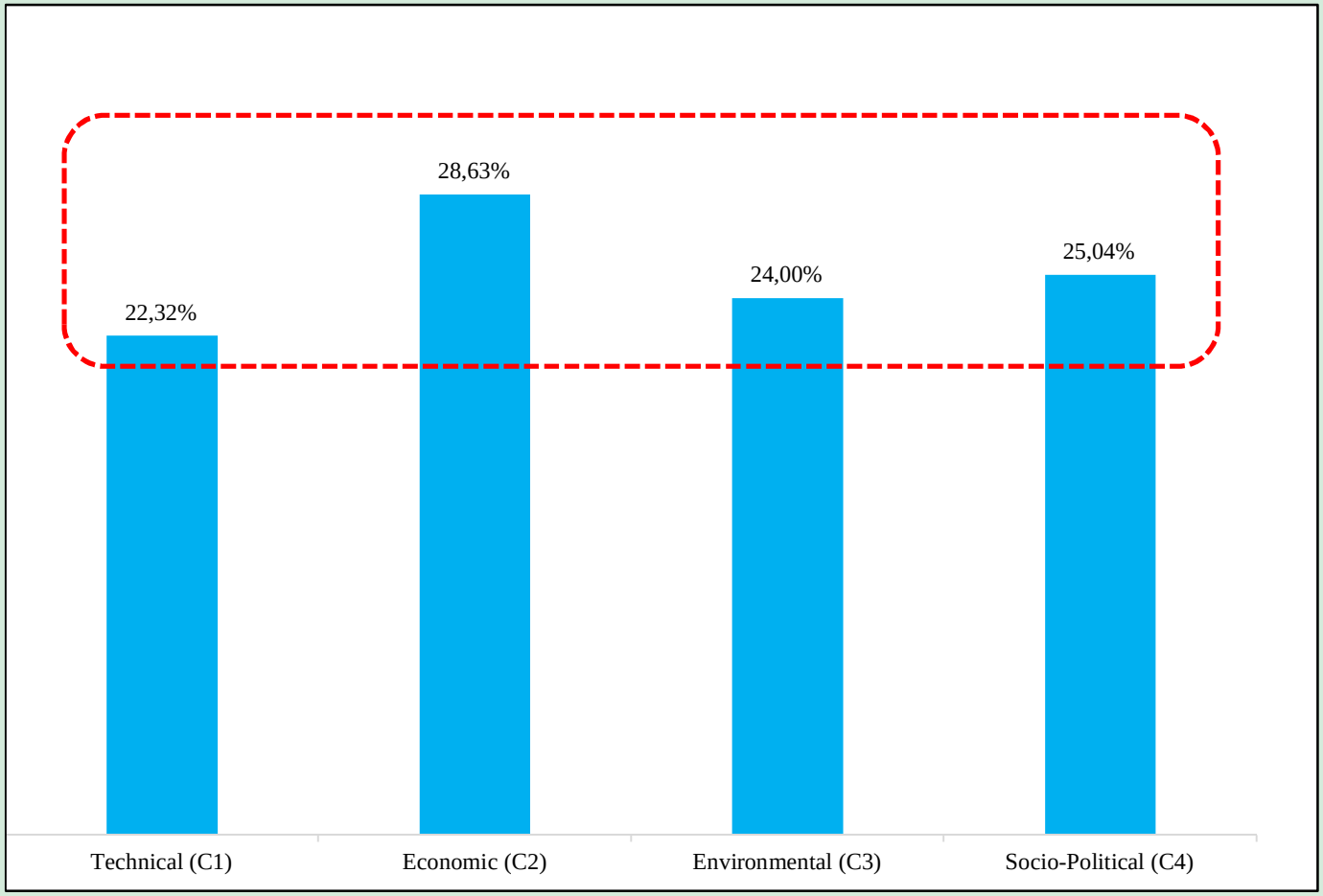
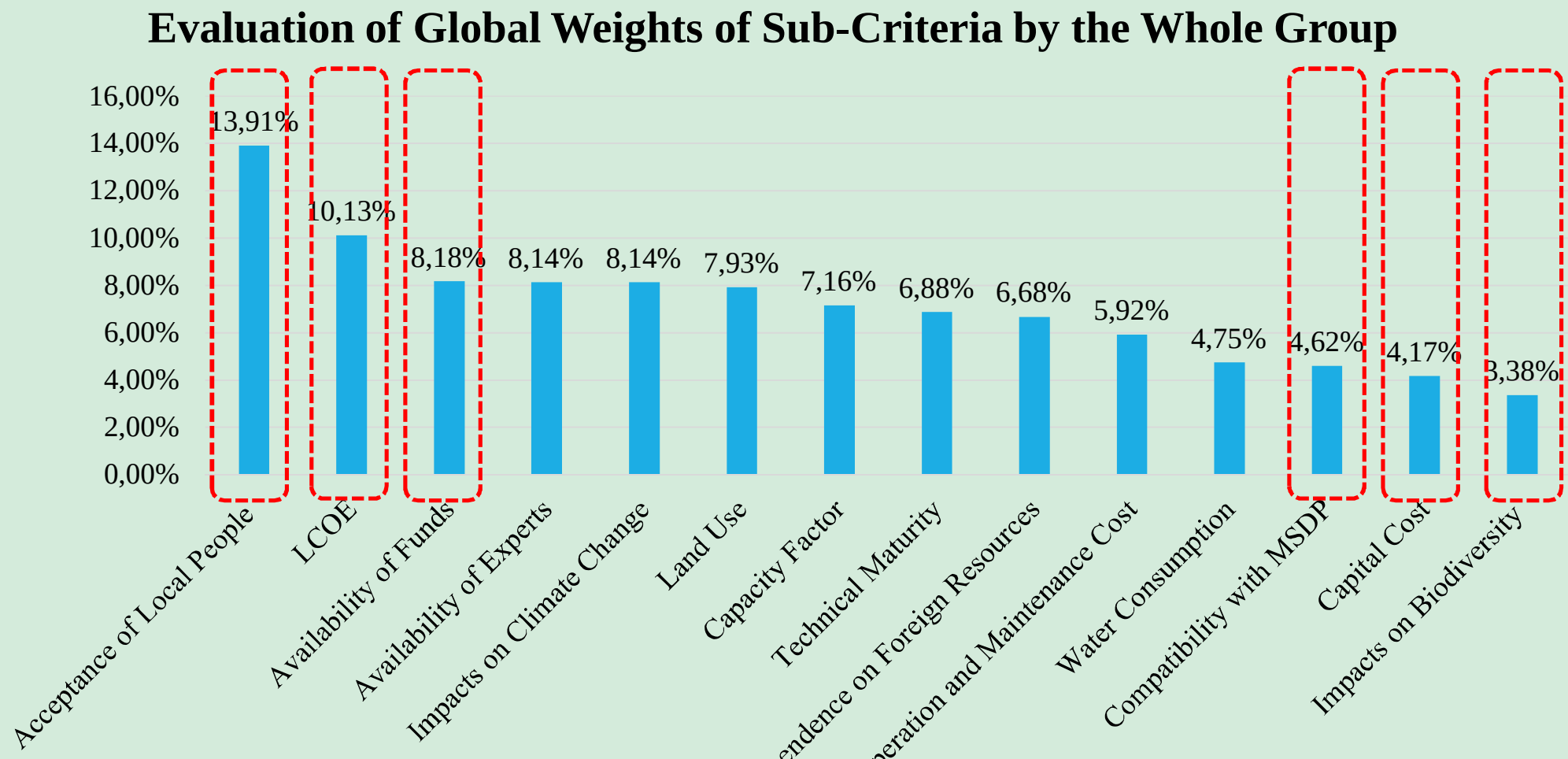
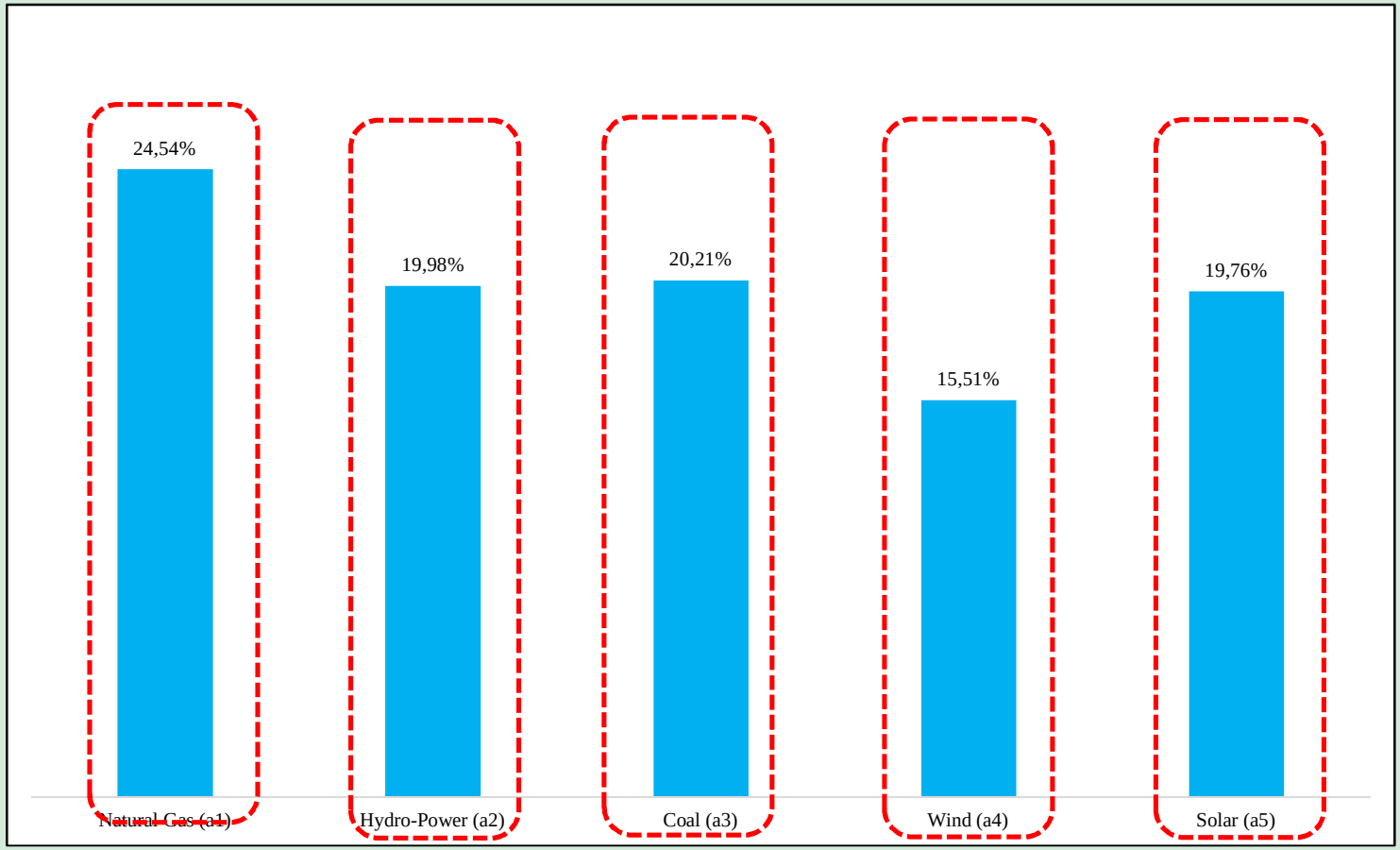
Economic	26,3	29,5	31,2	27,2	34,7
Environmental	30,6	18,7	22,9	26,1	21,8
Socio-Political	26,5	25,7	22,9	24,3	20,6

Evaluation of Main Criteria by Whole Group




Evaluation of Global Weights of Sub-Criteria by the Whole Group
16,00%
14,00%
12,00%
10,00%
8,00%
6,00%
4,00%
2,00%
0,00%
13,91%
10,13%
8,18%
8,14%
8,14%
7,93%
7,16%
6,88%
6,68%
5,92%
4,75%
4,62%
4,17%
3,38%
Acceptance of Local People
LCOE
Availability of Funds
Availability of Experts
Impacts on Climate Change
Land Use
Capacity Factor
Technical Maturity
Dependence on Foreign Resources
Operation and Maintenance Cost
Water Consumption
Compatibility with MSDP
Capital Cost
Impacts on Biodiversity

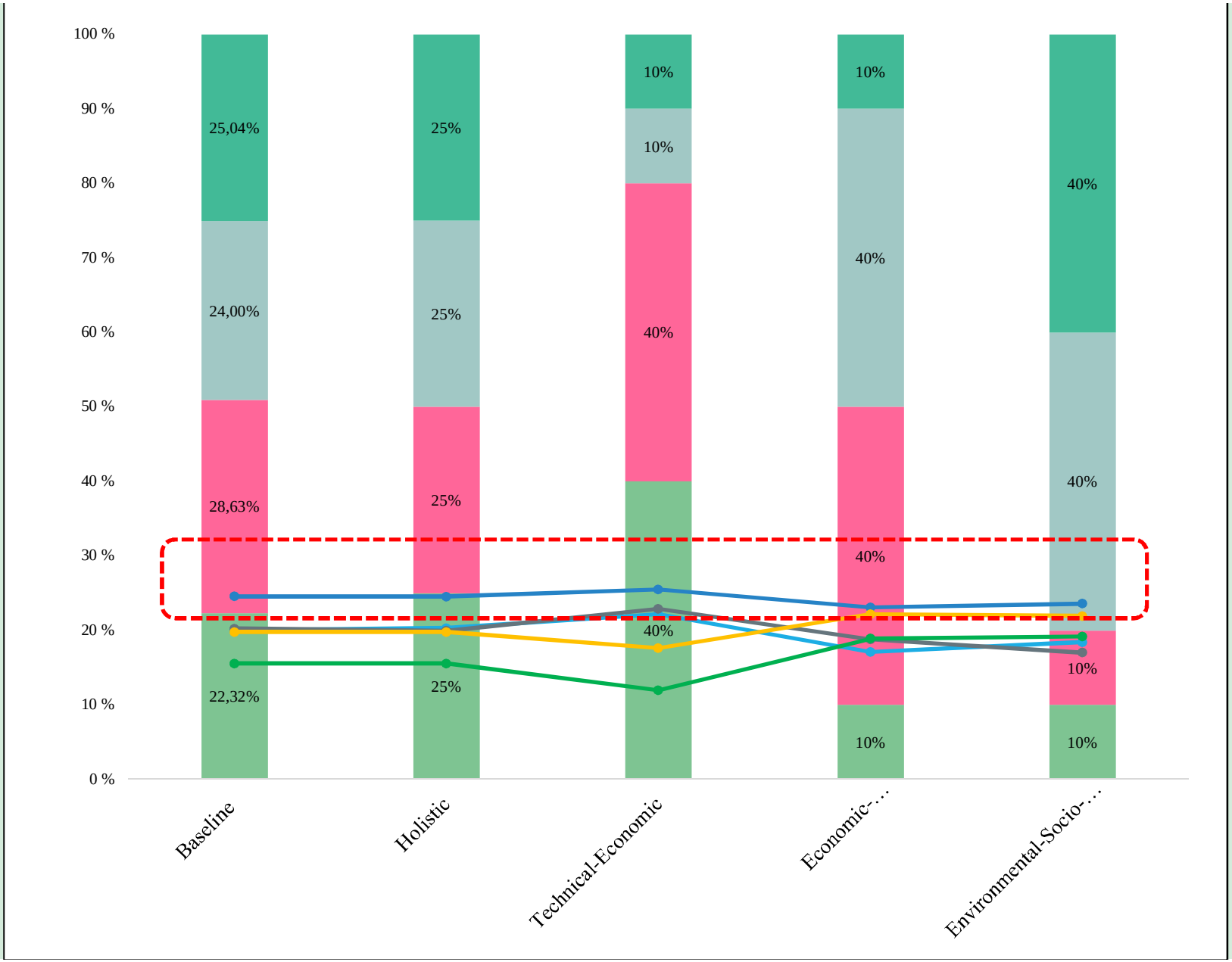
Evaluation of Alternatives by Whole-Group



Sensitivity Analysis

- **Five Scenarios**

1) **Scenario 1: Baseline Scenario(**Eco - 28.63%, Env- 24.00%, Socio- 25.04%, Tech- 22.32%)
2) **Scenario 2: Holistic Scenario (**Eco – 25%, Env- 25%, Socio- 25%, Tech- 25%)
3) **Scenario 3: Technical-Economic Scenario (**Eco – 40%, Env- 10%, Socio- 10%, Tech- 40%)
4) **Scenario 4: Economic-Environmental Scenario (**Eco – 40%, Env- 40%, Socio- 10%, Tech- 10%)
5) **Scenario 5: Environmental-Socio-Political Scenario (**Eco - 10%, Env- 40%, Socio- 40%, Tech- 10%)


100 %
90 %
80 %
70 %
60 %
50 %
40 %
30 %
20 %
10 %
0 %
25,04%
24,00%
28,63%
22,32%
25%
25%
25%
25%
10%
10%
40%
40%
40%
40%
40%
40%
40%
10%
10%
10%
Baseline
Holistic
Technical-Economic
Economic-…
Environmental-Socio-…

Conclusion

- **Research Questions**

1. **Which criteria should be used to evaluate electricity generation technologies?**
2. **Which criteria and sub-criteria should be paid more attention in the decision-making process for choosing proper generation technologies for electricity generation in Myanmar?**
3. **Which generation technologies are more preferable to be adopted for electricity generation in Myanmar?**

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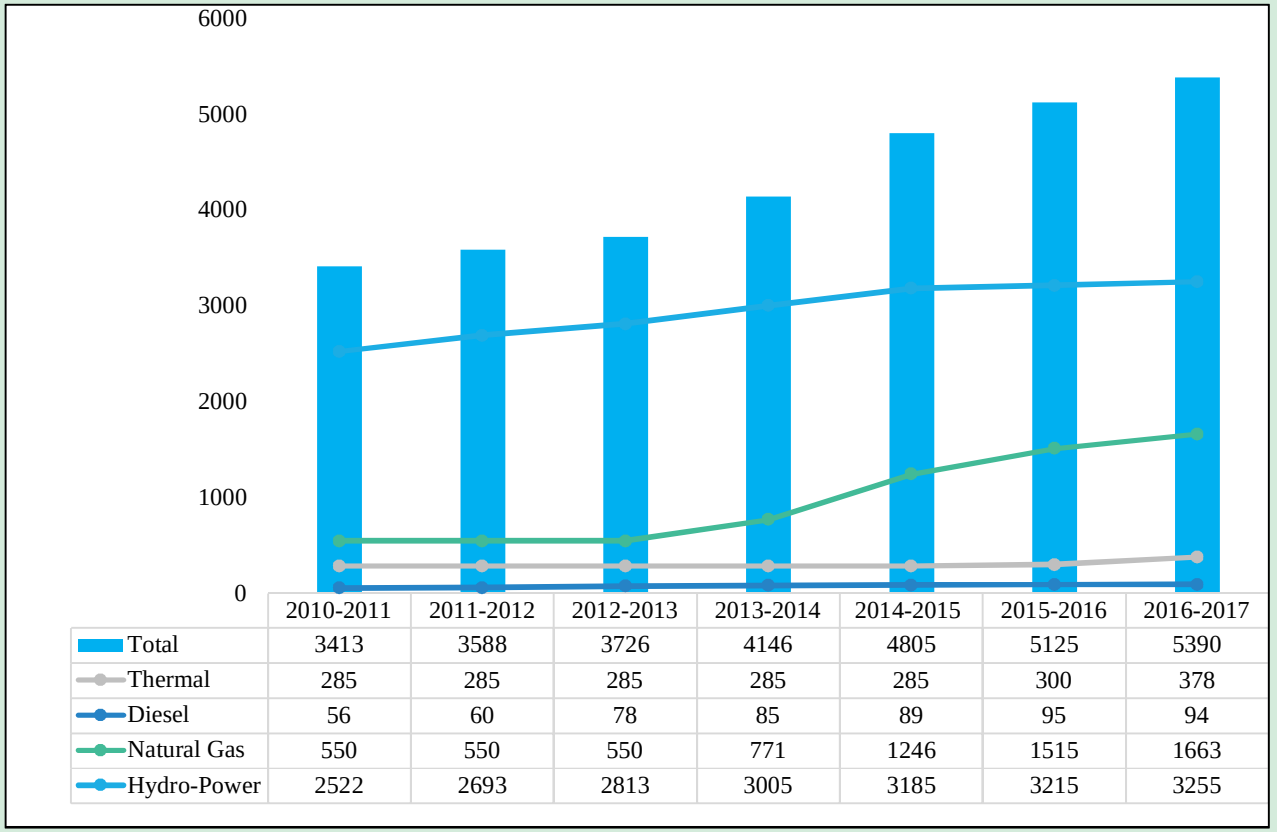
Thank You For Your Attention!

2. Electricity Status in Myanmar

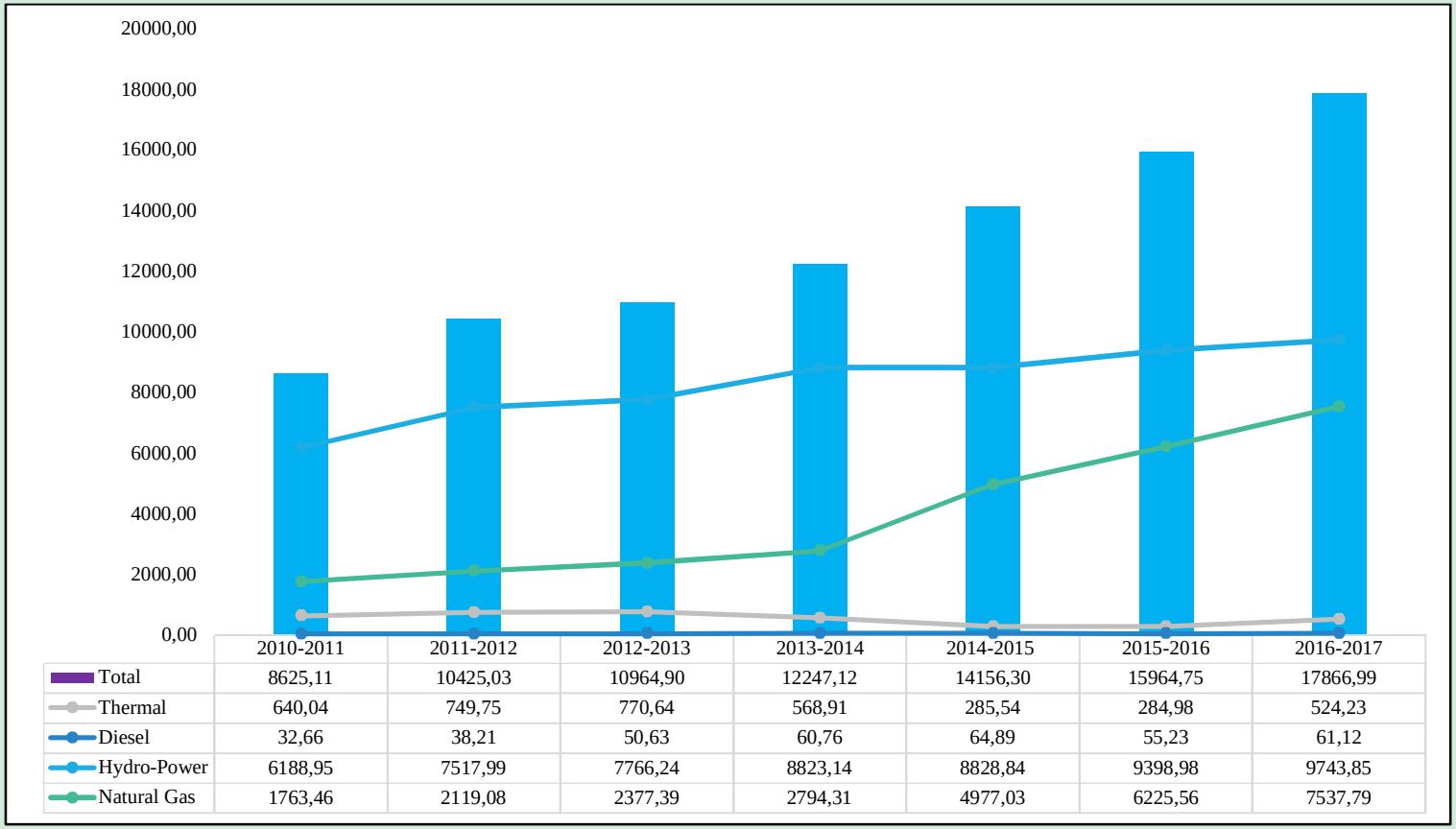
Installed Capacity (MW)



	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017
Total	3413	3588	3726	4146	4805	5125	5390
Thermal	285	285	285	285	285	300	378
Diesel	56	60	78	85	89	95	94
Natural Gas	550	550	550	771	1246	1515	1663
Hydro-Power	2522	2693	2813	3005	3185	3215	3255

2. Electricity Status in Myanmar

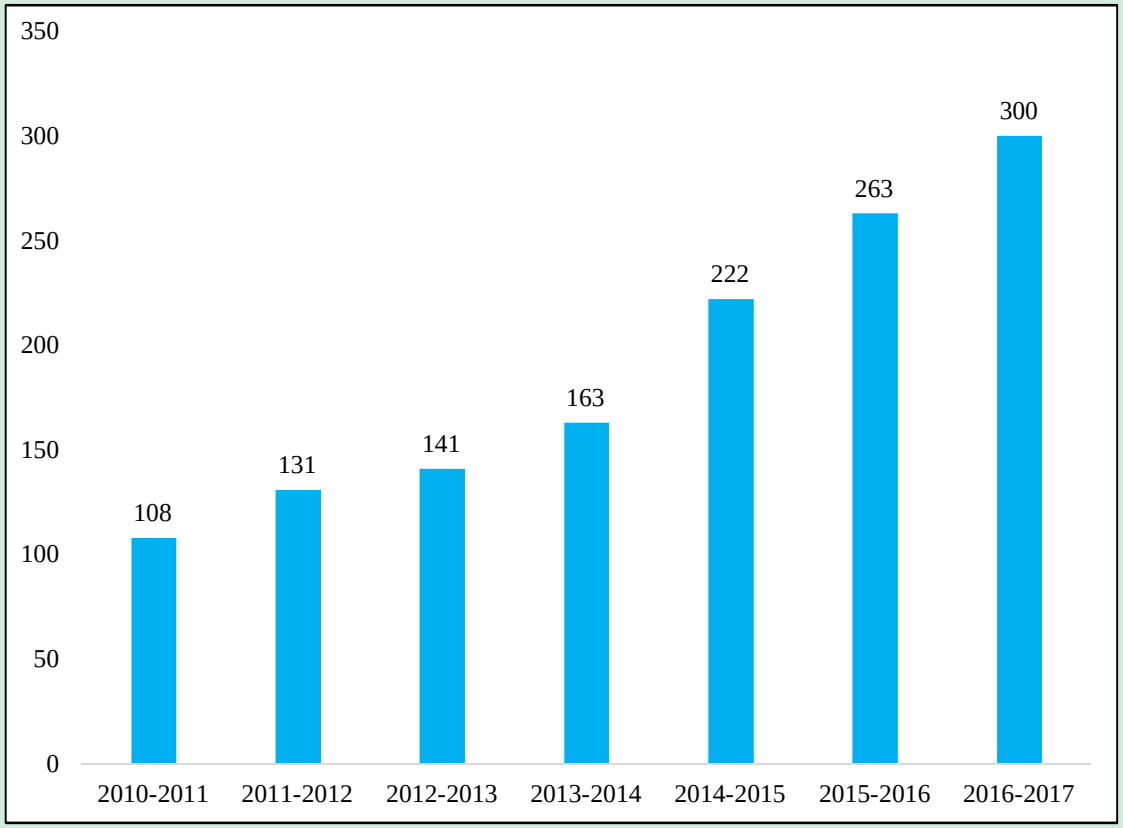
Electricity Generation (Million kWh)



	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017
Total	8625,11	10425,03	10964,90	12247,12	14156,30	15964,75	17866,99
Thermal	640,04	749,75	770,64	568,91	285,54	284,98	524,23
Diesel	32,66	38,21	50,63	60,76	64,89	55,23	61,12
Hydro-Power	6188,95	7517,99	7766,24	8823,14	8828,84	9398,98	9743,85
Natural Gas	1763,46	2119,08	2377,39	2794,31	4977,03	6225,56	7537,79

2. Electricity Status in Myanmar

Electricity Consumption Per Capita (kWh)



2. Electricity Status in Myanmar

Total Electricity Consumption Per Capita (GWh)