Presentation

on

Analysis of Small-Scale Renewable Energy Options for Electricity Supply in Coastal Areas

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Introduction

Background

- **Extending grid to Coastal areas**
  - ❖**Not economically viable and effective**
    - ➢high investment in transmission and distribution network,
    - ➢ high transmission loss,
    - ➢high poverty, low population density, low electricity demand.
  - ❖**Technically difficult** due to long-time for grid extension.
- Small-scale RETs: locally available, reliable, affordable and sustainable, meet the electricity needs of the populations and support local economic activities - **improving the living conditions of poor people and communities in coastal areas**.

Selection and Prioritization of Key Barriers for Deployment of Small-scale RETs in Coastal Areas

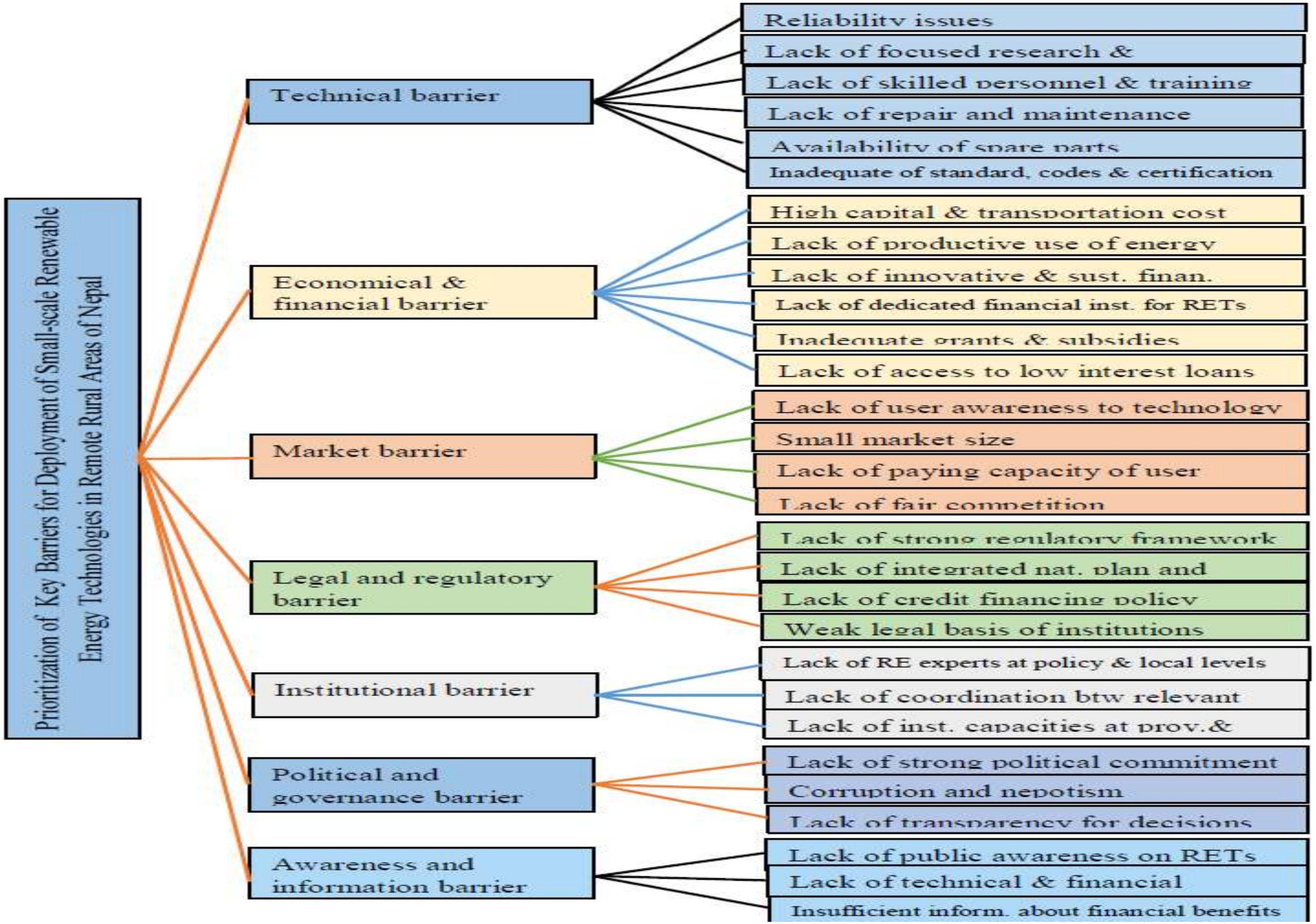
Why selection of Small-Scale RETs?

- The small-scale RETs as the potential technologies for reliable and affordable electricity solution in coastal areas.

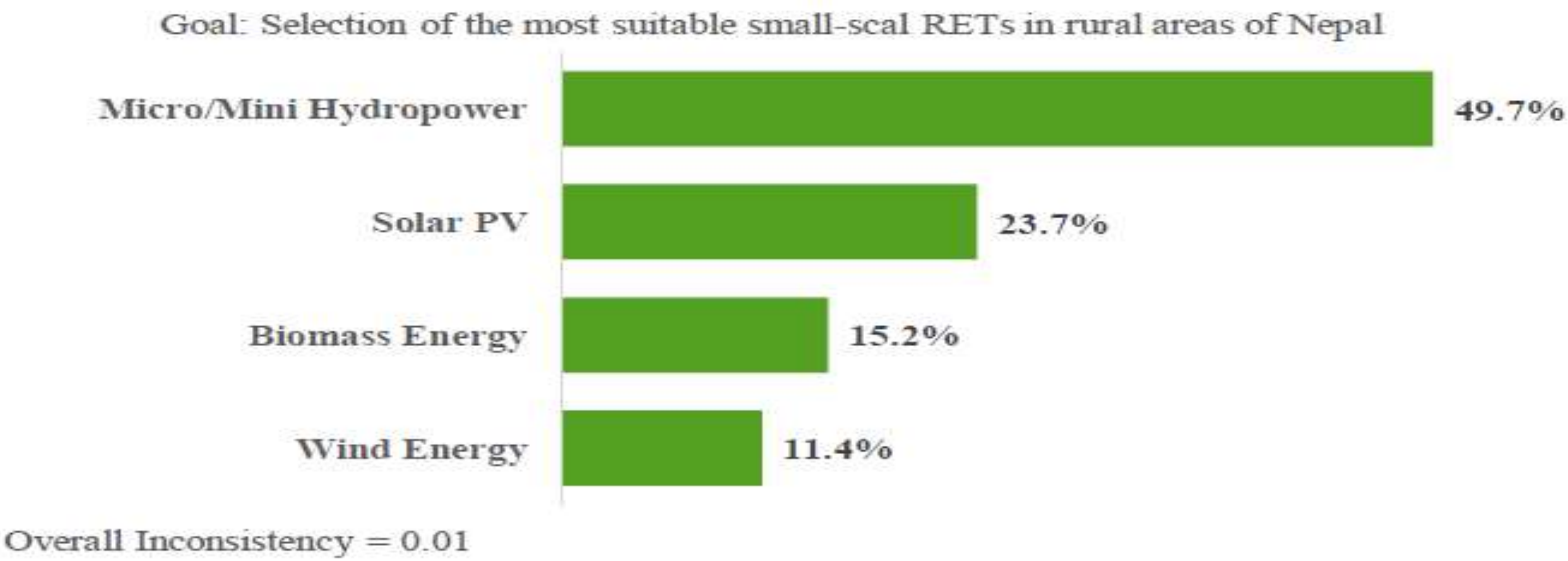
- The lack of selection of appropriate small-scale RETs hindering the expansion for electrification **(different factors such as resource availability, cost, economic viability, environmental aspects, social acceptance, government policy)**.

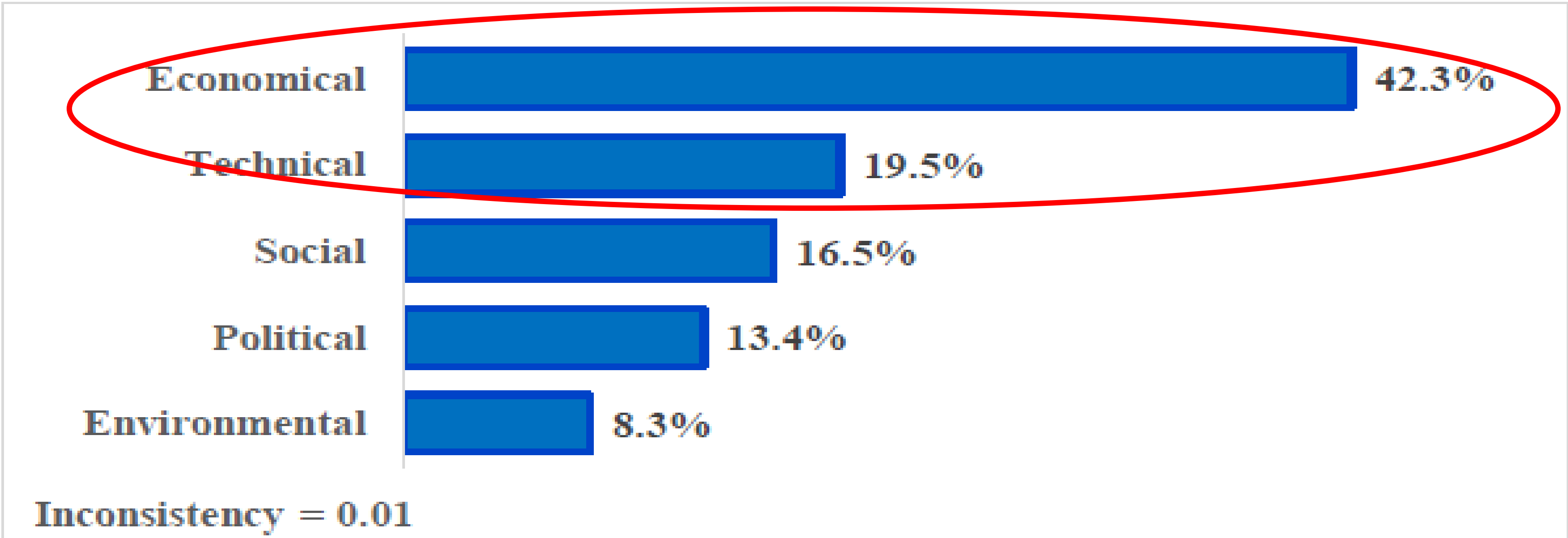
- **Long-term goal**: ensuring energy access to all and enhancing energy security and supporting the electrification.
- Selecting the most suitable small-scale RETs and prioritizing barriers for increasing the access to electricity in coastal areas.

Hierarchical Structure for Prioritization of Barriers-RETs

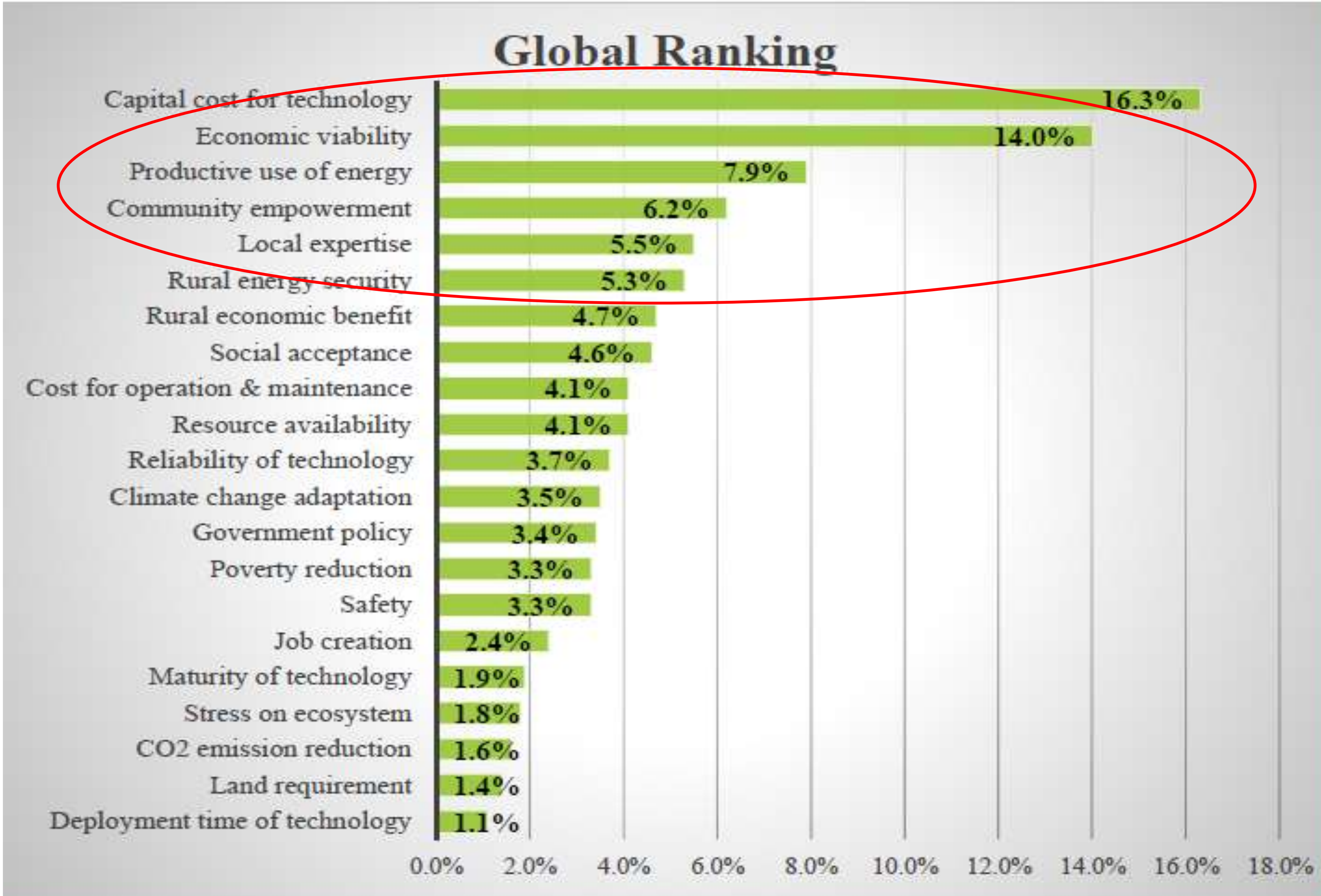


Results - Selection of the Small-scale RETs

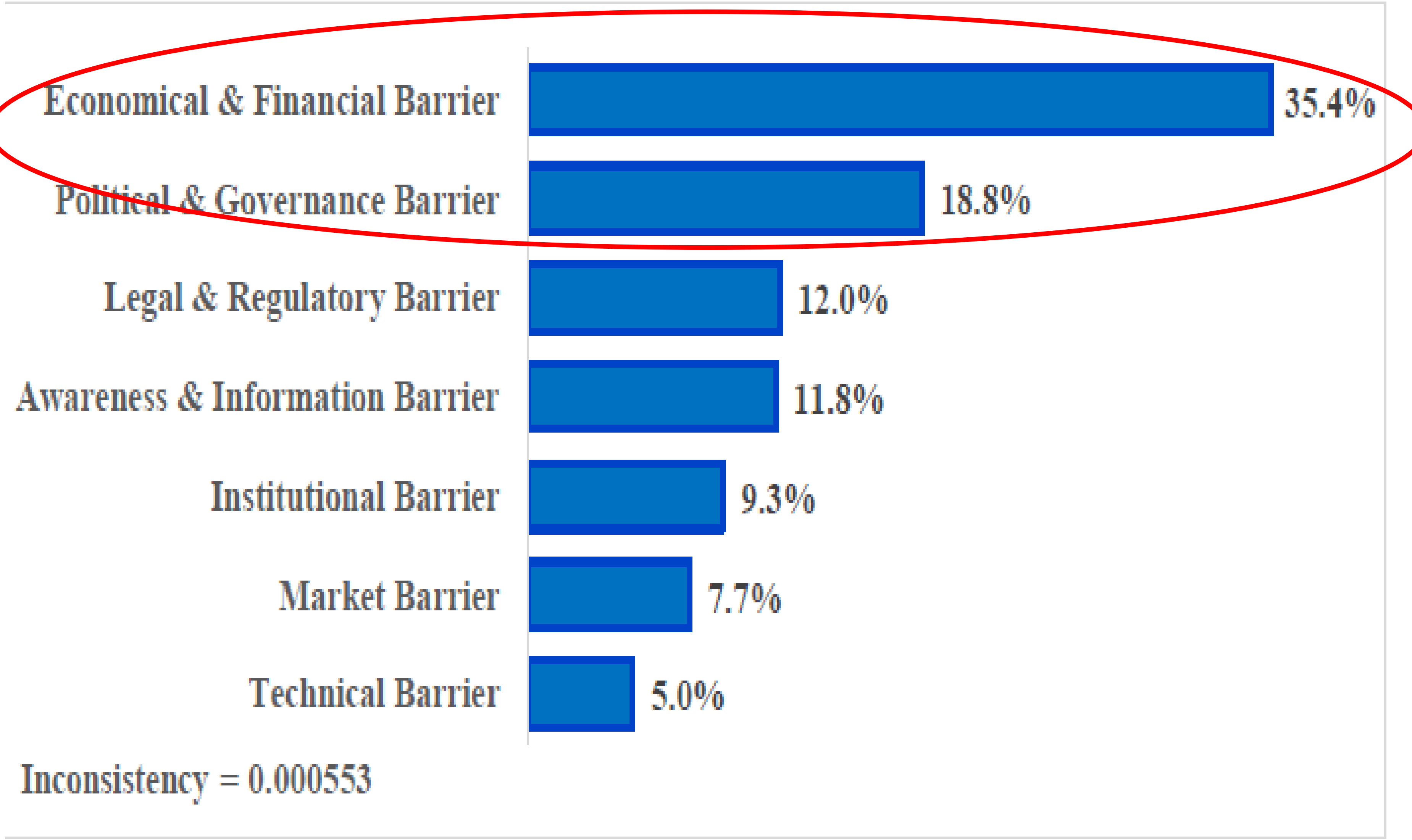




Results - Selection of the Small-scale RETs….



Results – Prioritization of Key Barriers for Deployment of Small-scale RETs



Results – Prioritization of Key Barriers for Deployment of Small-scale RETs…

Discussion- Selection of Small-scale RETs

- Micro/mini hydropower most preferred technology among the small-scale RETs for remote areas. However, local condition not suitable in all the locations of the remote areas due to **geographical difficulties and low water flow in dry season**.

- Biomass energy the 3rd most preferred but not sufficiently available in mountain areas and **uncertainty of supply due to seasonality** in most of the coastal areas.

- Solar energy resource available in all locations and high wind energy resources in the areas of low water flow and less biomass resource.

Discussion- Prioritization of Barriers for Small-scale RETs

- The economic and financial barrier as the most important barrier for small-scale RETs in remote areas – **low HHs income, high risk for financing small-scale RETs; small loan size; low productive energy uses due to lack of information, entrepreneurship skill & market access for goods; very limited FIs**.
- Though inadequate grant & subsidy not observed as important barrier, several studies indicated **low subsidy for poor and remote areas** hindering the access to technologies.
- Political and governance barrier as the second most barrier due to lack of political commitment and corruption in decision.

Discussion- Recommendations for Removal of Barriers for Small-scale RETs

- **Access to credit**: sharing risk for financing small-scale RETs among government, FIs and users; insurance to technologies for failure, damages (e.g. fire, land slides).

- **Extensive promotion of productive end uses** of electricity: entrepreneurship skill training, market linkage for goods and services, provision of seed money for start-up the small-scale business.

- **Political commitment**: education and awareness of importance of small-scale RETs for poverty reduction, improving social services, sustainable economic development.

- **Increase the transparency and good governance** in decision making for deployment of small-scale RETs.

Techno-economic Assessment of Off-grid Hybrid Small-scale Renewable Energy System for Electricity Supply in Coastal Areas

Why Off-grid Hybrid Small-scale RE system?

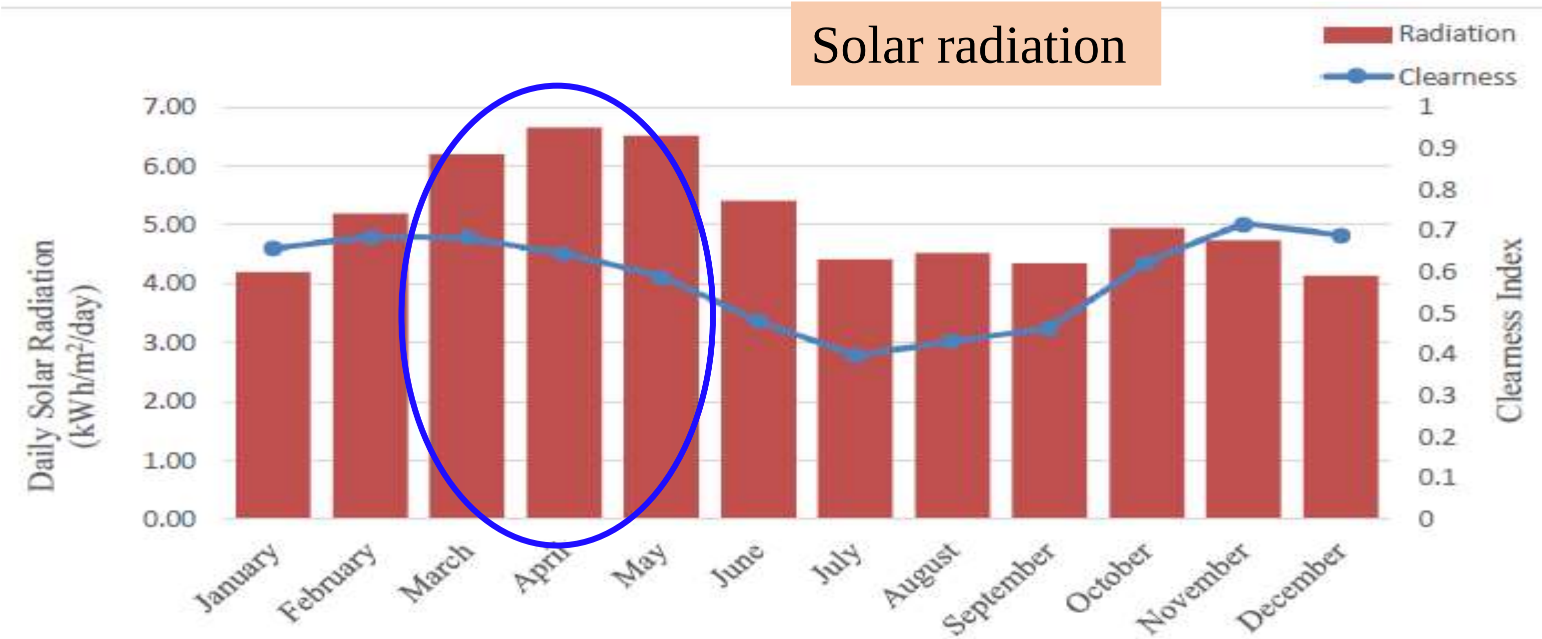
- The off-grid RE options are more suitable in coastal areas for supply of reliable and high quality electricity.

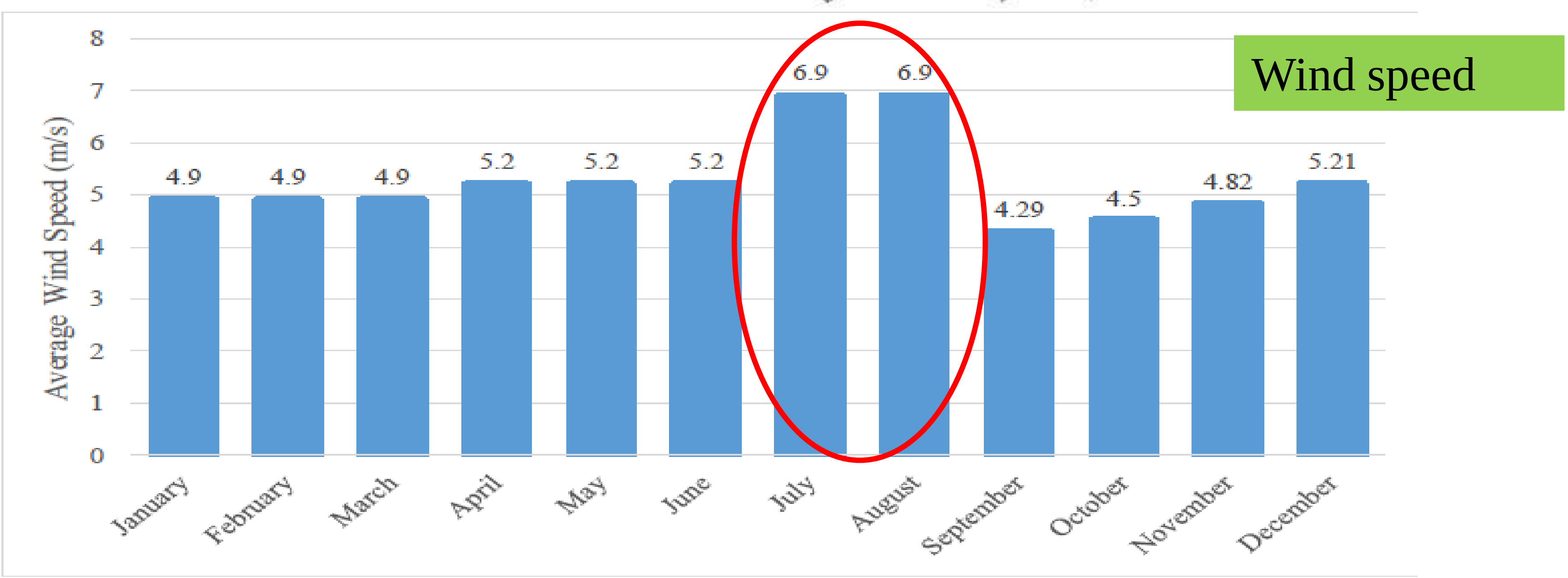
- Single source of intermittent nature of RE resources (solar energy and wind energy) not continuously secured and cannot meet peak demand.

- The combination of more than one RE source mainly **solar energy** (sunny daytime), and **wind energy** (during night and cloudy day) with storage battery can enhance system efficiency, offer **more reliability and greater balancing** the electricity supply.

- **Economic and technical factors** major determinant for deploying small-scale RETs in coastal areas.

Data Input: Solar and Wind Resources





Results- System Architecture

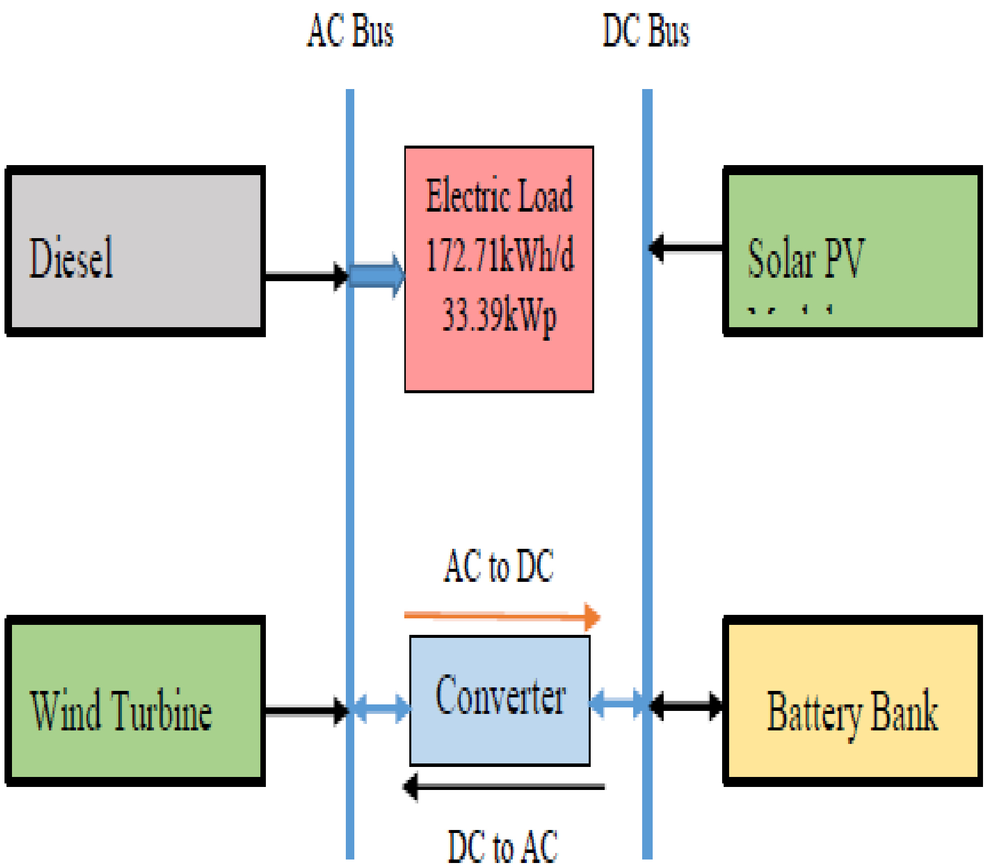
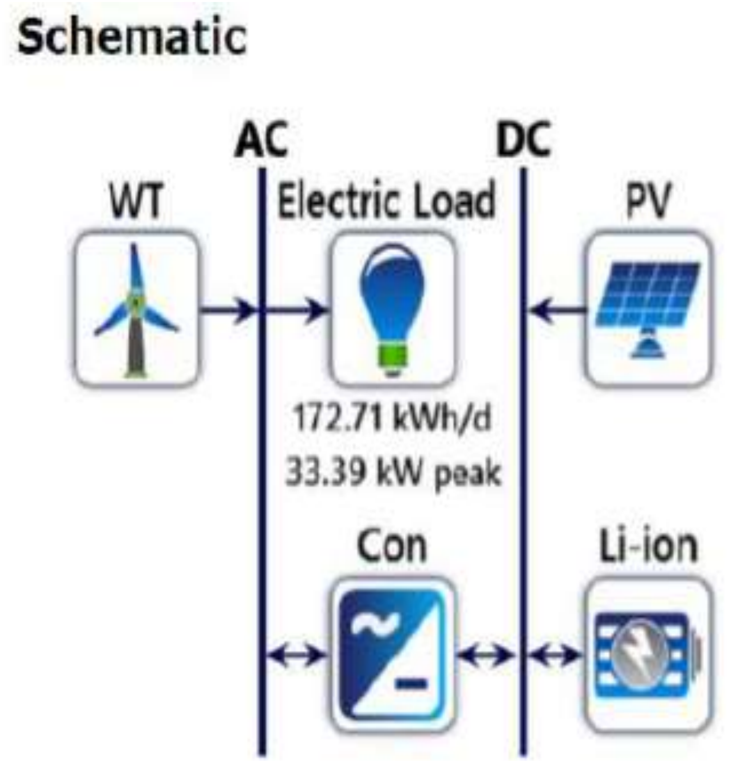


Figure 3 8 Hybrid energy system design



Results – Optimization (with and without DG)

Architecture						Cost							System
SN	Solar PV (kW)	Wind Turbine (kW)	Diesel Gen (kW)	Li-ion Battery (Nos.)	Converter (kW)	**NPC ($)**	**COE ($/kWh)**	Operating cost ($)	Initial cost ($)	Fuel cost ($)	O&M cost ($)	Ren Frac (%)
H1	53.1		25	49	29.5	**235,491**	**0.355**	6,888	163,094	1,923	4,935	89.1
H2	46.9	10	25	48	28.7	**247,965**	**0.374**	6,584	178,759	1,452	5,245	91.8
H3	131			101	32.5	**281,075**	**0.427**	5,497	223,301	0	5,769	100
H4	141	10		68	35.1	**296,634**	**0.451**	5,920	234,412	0	6,211	100
H5	52		25		19.8	**334,286**	**0.505**	19,249	131,967	13,324	5,263	27
H6	51.8	10	25		19.8	**340,930**	**0.515**	17,986	151,884	11,829	5,602	35.6
H7		40	25	27	6.27	**356,990**	**0.540**	16,132	187,431	9,770	6,021	40
H8		60	25			**441,734**	**0.668**	22,052	209,945	14,477	6,928	14.2
H9		210		483	40.8	**906,661**	**1.38**	13,720	762,450	0	13,720	100

Results - Sensitivity Analysis

Diesel fuel price ($/Liter)	Maximum annual capacity shortage (%)	Capital cost of RETs and storage battery (multiplier)		
		Solar PV (module)	Wind turbine	Li-ion battery
0.74	1	**1**	1	**1**
0.9	0	**0.8**	0.9	**0.9**
1.0	10	**0.6**	0.8	**0.8**
1.1		**0.4**	0.7	**0.7**

Results - Sensitivity Analysis…..

Variation of NPC and COE with other parameter (with diesel generator)

Variable	Range	NPC ($)	COE ($/kWh)
Diesel fuel price	0.74-1.10 ($/L)	235,491 - 243,513	0.355 - 0.368
Annual capacity shortage	**0-10%**	**235,491 - 211,412**	**0.355 - 0.344**
Cost of Solar PV module (multiplier)	**1-0.4**	**235,491 - 216,529**	**0.355 - 0.327**
Cost of Li-ion Battery (Multiplier)	1-0.7	235,491 - 227,142	0.355 - 0.343

Variation of NPC and COE with other parameter (without diesel generator)

Variable	Range	NPC ($)	COE ($/kWh)
Annual capacity shortage	**0-10%**	**324,963 - 211,412**	**0.491 - 0.344**
Cost of Solar PV (multiplier)	1-0.4	281,075 - 233,111	0.427 - 0.354
Cost of Li-ion Battery (Multiplier)	1-0.7	281,075 - 265,962	0.427 - 0.404

Discussion

- Hybrid system without diesel generator not recommended in the study village due to high fuel cost, supply uncertainty, high expertise for maintenance, and not good for environment.

SN	Hybrid system	NPC ($)	COE ($/kWh)	Annual Electricity (kWh)				Emission kg/year (CO_2/CO)
				Demand	Supply	Excess	Shortage	
1.	**Solar PV/DG/Battery**	**235,491**	**0.355**	**63,039**	**95,719**	**29,941 (31.3%)**	**56 (0.1%)**	**6,835/42.7**
2.	Solar PV/Battery	281,075	0.427	63,039	219,867	154,541 (70.3%)	692 (1.1%)	0
3.	Solar PV/Wind/ Battery	296,634	0.451	63,039	245,936	180,990 (73.6%)	680 (1.08%)	0

- Hybrid system of 100% RE and more than one source (solar PV and wind turbine with battery storage) more reliable and sustainable, and less number of batteries.

- The higher annual capacity shortage (10%), costs reduction of solar PV modules (60%), wind turbine (30%) and Li-ion battery (30%) significantly **reduce the NPC and COE** of the hybrid system.

Sustainability of the Existing Off-grid Hybrid Small-scale RE Systems

Introduction

- Designing an optimal hybrid system does not ensure the **sustainable operation** for uninterrupted supply of the electricity.

- The sustainability of the off-grid RE projects not taken into consideration - raising the **questions of their long-term performance**.

- Most of the off-grid RE hybrid systems facing technical failures and financial crises seriously compromising the sustainability of the systems. Mostly lacking economic, social and technical sustainability.

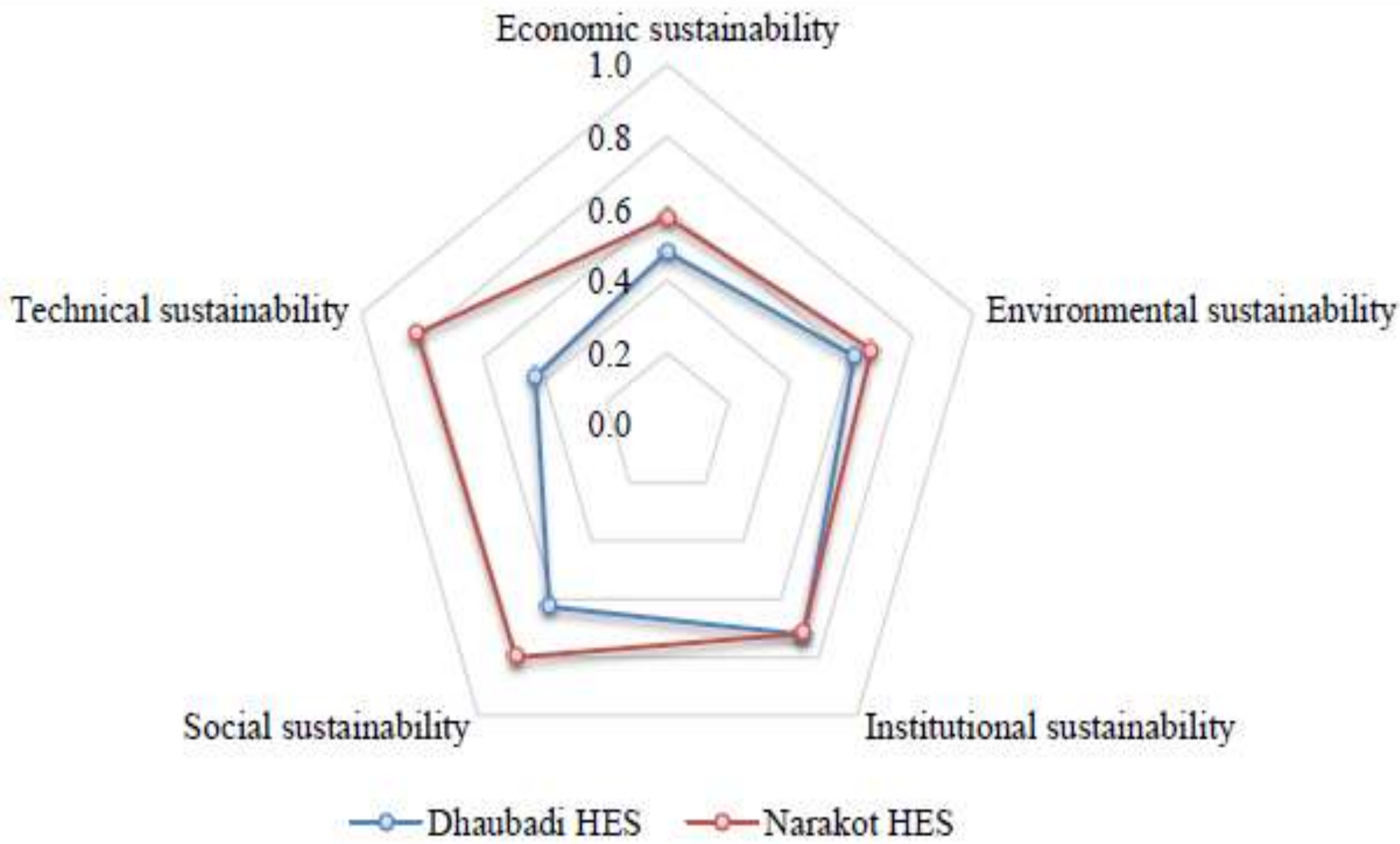
- Main aim - **assess the sustainability of the off-grid hybrid small-scale RE systems** and support the government to **improve the design considering the sustainability perspective.**

Theoretical Framework

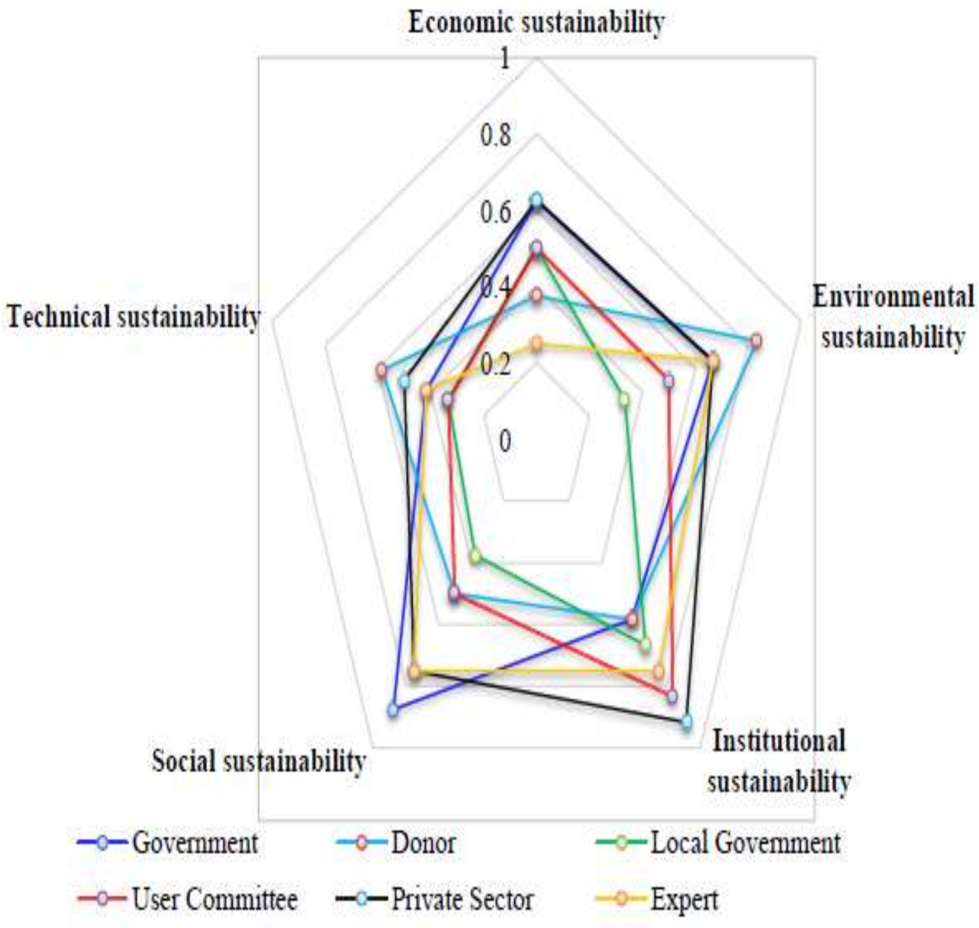
Sustainability framework comprising economic, environmental, institutional, social and technical applied for the case study.

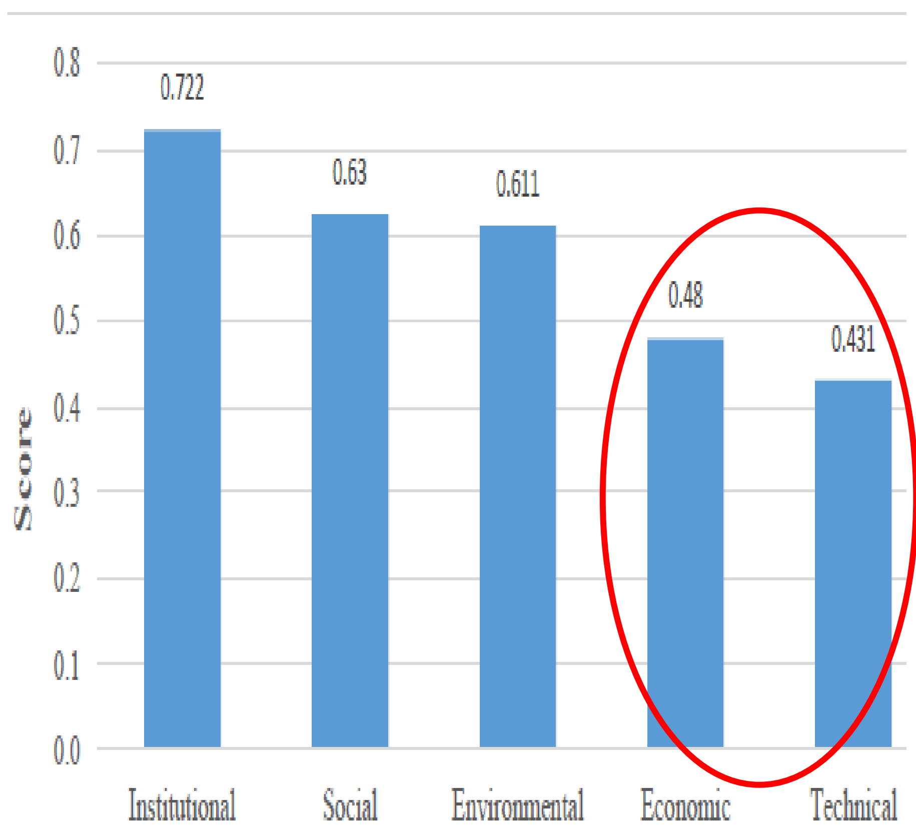
Economic	Environmental	Institutional	Social	Technical
1. Affordability of electricity for users 2. **Generation of enough revenue for O&M** 3. Use of electricity for economic/ productive activities 4. Increase of households' income from electricity services	1. Electricity replaced the polluted energy sources for lighting (such as kerosene) 2. Electricity reduced polluted energy sources for cooking (such as fuel-wood, kerosene) 3. No adverse local impact is observed	1. Management committee is effective & efficient 2. Operator of hybrid system is active & capable 3. Non-technical losses are minimized 4. Consumer's satisfaction with electricity service 5. Effective system to lodge & address complaints 6. Effective system for account keeping & public hearing	1. Electricity improved education service 2. Electricity improved health service 3. Other social services improvement from electricity (streetlights, police patrol) 4. Less burden to women due to electricity	1. Capacity of system meets present and future demand 2. Safe to operate & timely maintenance 3. Reliability of electricity service 4. Support infrastructure availability (spare parts, expertise) 5. Efficient system, low technical losses 6. Compatibility with grid connection in future

Results

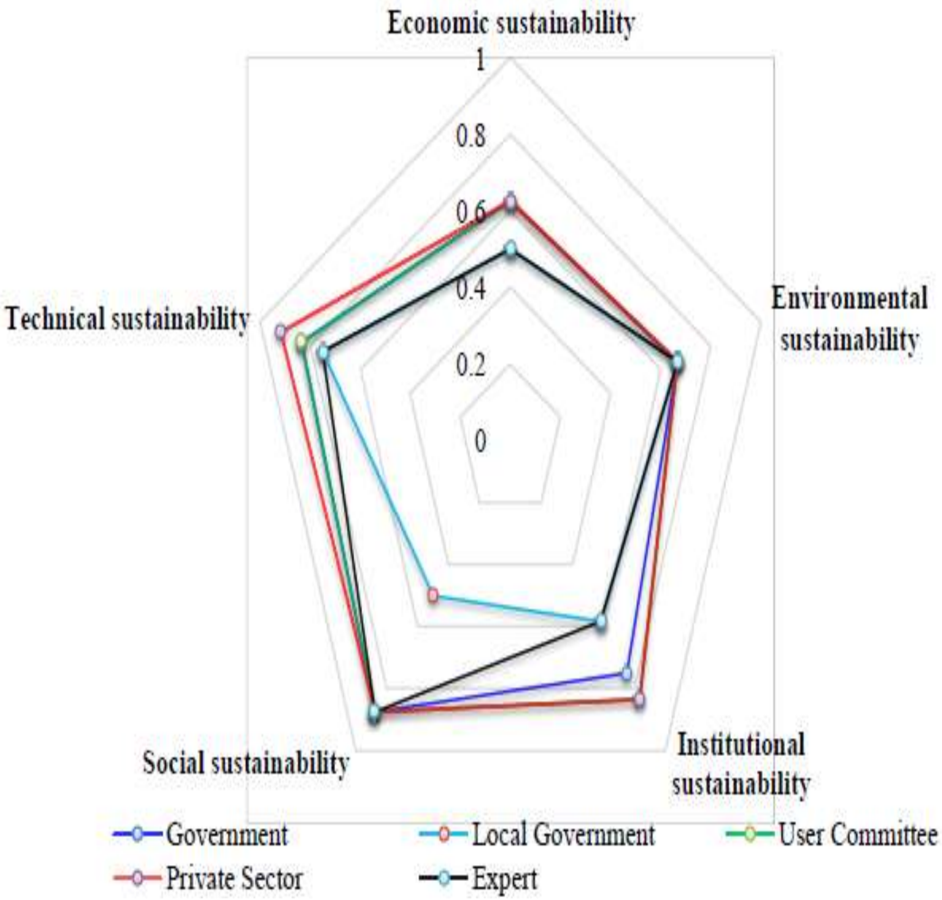

Economic sustainability
1.0
0.8
0.6
0.4
0.2
0.0
Environmental sustainability
Institutional sustainability
Social sustainability
Technical sustainability
Dhaubadi HES
Narakot HES

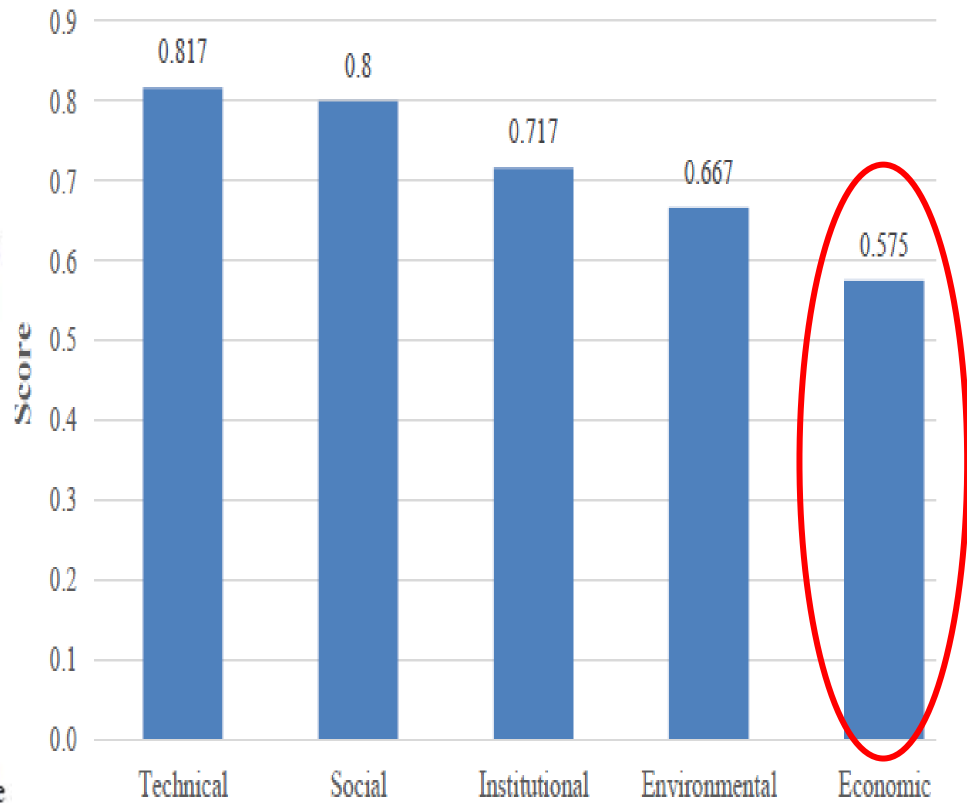
Results: Sustainability of Dhaubadi Hybrid System





Results: Sustainability of Hybrid System





Discussion

- Very low technical performance of the hybrid system due to non-functioning of wind turbine - **low quality wind turbine, no warranty & guarantee, low technical capability of local company**. **No national technical standard.**

- Some hybrid system have better economic performance but some are facing challenges for economic sustainability. **No business plan for use of electricity for households and productive uses (Planned during designing but not implemented).** Low electricity supply from hybrid system – hampering productive uses.

- The overall performance of the two hybrid systems in terms of sustainability differs due to different governance structure.

- The sustainability assessment should be part of the monitoring of the hybrid system.

Policy Recommendations

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- Removal of barriers through framing policies and regulatory framework, **providing financial incentives & diversifying productive end uses**.

- Designing of hybrid system based on **reliable resource assessment** of various RE with long-time measured data.

- Development of **national technical design and standard** for off-grid hybrid RE system to maintain the minimum technical standard.

- Improvement in **technical design**, compatibility with grid connection, strengthen the institutions, **availability of spare parts**, and promotion of end uses.

- Implementation of the **central remote monitoring system** for off-grid hybrid system to assess the performance & improve the sustainability.

Conclusions

- Small-scale RETs as **core component to reduce the poverty** through improving social services and supporting local economic activities.

- The micro and mini hydro power, solar PV, biomass energy and wind energy the most preferred technologies in priority order, whereas economical & financial barrier, political & governance, and legal & regulatory barriers observed as the most important barriers.

- Techno-economic assessment of solar PV/Wind turbine/battery hybrid system observed as the most suitable option for reliable electricity supply in the study area.

- The off-grid hybrid systems are lacking the sustainability in terms of **economic, environment, institutional, social and technical** aspects even though one better performed than other.

Thank You So Much