Proceedings of IOE Graduate Conference, 2015
pp. 134–142

Decentralized Energy Units Practice in Nepal with its Challenges, Opportunities and Strategic Options

Sudan Kayastha[1]*, Bhakta Bahadur Ale[2]

[1,2] *Department of Mechanical Engineering, Pulchowk Campus, Institute of Engineering, Tribhuvan University, Nepal*
***Corresponding author**: kayasthasudan@gmail.com

Abstract
This study attempts on investigation of existing challenges and the future prospects of sustainable renewable energy development in Nepal through decentralized energy units. Mixed method was employed to assess it; the top-down approach was used to understand the energy use pattern, the future forecasting, the challenges and the opportunities with the national experts and macro-level economic assumption. Whereas the bottom-up approach was used to end- use perspective of local level agencies. The business as usual (BAU) scenario was forecasted from population growth and national GDP whereas two policy scenarios i.e. Renewable Energy Technologies (RETs) Intervention scenario and Micro-hydro Promotion (MHP) scenario were demonstrated to supply growing energy demand. The overall energy consumption of rural residential sector in year 2012 was 267 million GJ and is forecasted to be 433 million GJ in the year 2050. The cluster level energy demands were identified and corresponding energy supply in both RETs and MHP scenario were presented. This study marked that the Units in the district have hard challenges on the institutional arrangement and policy setup, whereas the capacity development is required about the technical skill along with the governance and social expertise for the promotion and development of renewable energy in local level.

Keywords
Energy Units – Challenges – Energy Scenario

1. Introduction

Access to clean, easy and affordable energy is an important factor to reduce poverty and achieve sustainable energy development in rural area. Investment in local level is a prerequisite to improve and ensure sustained efforts to expand energy access in rural areas. This is particularly true when energy access programmes target poor and rural populations through off-grid energy technologies, where traditional delivery mechanisms, such as central utilities, are highly constrained to take on these challenges due to geographical remoteness and small and/or fragmented markets. In such circumstances, more innovative delivery mechanisms are needed, where a variety of local actors including local authorities, local private entities, civil society organizations, and communities necessarily play a central role in delivering energy services to people with adequate authority and capable organizational structure in local bodies to endorse it. In line with the spirit of the Local Self Governance, local government bodies and representative agencies will have their active and effective roles in energy promotion. In all districts, Environment, Energy and Climate Change Sections (DEECS) have been established in DDC. Ministry of Federal Affairs and Local Development (MoFALD), under the concept of ”Environment Friendly Local Governance” has arranged this unit as the focal point for energy, environment and climate change at the local level. This unit is taken as decentralized energy units. The Government of Nepal (GoN) aims to electrify by the next 20 years, the share of renewable energy in total energy supply of the country will reach 10 percent and almost 30 percent of the people in the country will have access to electricity from alternative energy source[1]. So it is mandatory to make an appropriate strategy to reach the rural community which won't be fulfilled without taking the local authorities together. There are limited strategy and plan from the government side to strengthen the local energy units on the district which will replicate on the development of renewable

energy sectors, so appropriate plan and policy is essential for this and it will be fruitful for the policy maker and donor agencies to identify the present scenario and future perspective.

1.1 Objective of the Study

The main objective of this study is to investigate the existing challenges and future prospects of sustainable renewable energy access in Nepal through decentralized units.

The specific objectives of this study are:

- To identify the barriers and constraints experienced by decentralized energy units.
- To identify significant changes in renewable energy development brought through establishment of energy unit in local bodies.
- To identify types of capacity development needed on those units.
- To investigate the present energy situation and future energy demand.
- To develop the strategic options for the attractive development of renewable energy in Nepal.

1.2 Literature Review

Nepal is currently experiencing an energy crisis of unprecedented severity. It ranks 53 out of 64 countries in the Energy Development Index (EDI) with 0.102 [2]. Rural electrification stands to approximately 34 percent, but even urban areas face acute power shortages. It has one of the world‘s lowest rates of per capita electricity consumption, with an average of 80kWh annually. The gap between supply and demand of grid electricity is increasing every year, as the demand is growing more than 7% annually. A steady rise in demand is caused by rapid urbanization and increased industry growth rate, whereas the deficiency in generation capacity has been mainly due to frequent outages and high system losses, lack of investment resources and geography. Traditional sources of energy hold the major share in energy demand and its consumption in Nepal. Despite abundant resources and optimal possibility of energy production through such resources, energy crisis has been on the rise as a result of inability to attain notable success in hydro-electricity generation. Present share of energy consumption has also been dominated by the Traditional Fuel having more than 79% of total. Historical trend shows a similar division as well. Commercial and renewable is in increasing trend but is at very slow growth rate. Residential sector energy consumption dominated the other sector. About 83% share of energy is used in residential sector. The major renewable energy resources available abundantly in Nepal are hydro, solar, wind and some low temperature geothermal sites. Economically biomass, solar and hydro is seen to be attractive until today.

Decentralization has positive impact on empowerment and building of social ownership among the local people. It is effective in the conservation and effective use of natural resources. So the effective resource utilization present at the local level using the local resources in coordination and cooperation among the local individual is one of the most essential factors for the energy demand management. The available examples suggest that the policies, development planning and capacity building at the national and local level need to reinforce each other and be flexible over time. The decentralized energy service delivery is the form of energy supply to the gap in rural areas. An enabling environment is needed to support decentralization efforts otherwise local energy planning may not flourish, or may even be thwarted. In Nepal, for instance, decentralization efforts in energy were supported by a decentralization policy framework that outlined local authority in planning, implementing and monitoring mini and micro-hydropower generation, and without which local energy planning would not be possible [3]. In Nepal, the local capacity development was the keystone of the approach used to deal with bottlenecks in energy planning and coordination at the local level, resulting in significant improvements in service delivery.

2. Methodology

The necessary information regarding decentralization and the process of energy development are collected from books, internets, published national/ international journals, review articles, past project reports, etc. and author reviewed deeply through these literatures. In this study the mixed approach is applied, the top-down concept seek to understand the energy use pattern, the future forecasting, the challenges and the opportunities of the decentralized energy units and its overview with

policy formulation and the implementation from the perspective of the national level and macro-level economic assumption were carried out. Whereas the bottom-up looks at the same objective of end use perspective of the individual local level agencies along with their present status and willingness is grabbed from the survey on the sampled district.

As per the sample sizing 43 district are selected on random basis making the consideration that at least two district from each cluster and maximum five numbers from the cluster having the higher districts as shown in the Figure 1.

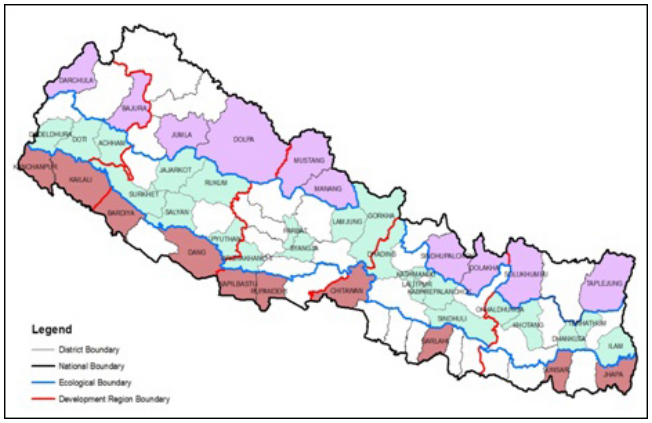

Figure 1: Selected District for Perception Study

By ascertaining the possible economic, behavioral and demographic parameters from the annual progress report of the district environment, energy and climate change sections and the reviewed literature the survey and questionnaire are designed. We have used an experimental research, design and creation research strategies to acquire the research objectives. Residential sector energy consumption is about 302.38 million GJ (81.99 %) in the year 2011/12 [4]. Moreover the axiom of the decentralized energy is to rural residential electrification/energy supply. The data was collected from the secondary source, National Survey of Energy Consumption and Supply Situation in Nepal 2012 from Water and Energy Commission Secretariat. The secondary data of energy consumption in rural residential sector for different end use was fed into the LEAP energy model to forecast the future energy demand and conduct the demand side management simulation analysis in three different circumstances: Business as Usual (BAU), Renewable Energy Technology (RETs) Intervention and Micro-hydro Promotion (MHP) Scenario. The preliminary demand analysis considers the energy used in rural residential sectors of Nepal. The residential sector is further analyzed with two sub sectors one is ecological belt (Mountain, Hill and Terai) and next is development region (EDR, CDR, WDR, MWDR, FWDR). The detailed practical methodology of the study is described in figure 2.

3. Result and Discussion

The total rural residential energy consumption in the year 2012 was 267.5 million GJ. As per the growing population the demand is projected to be 433.3 million GJ in year 2050 without any policy measure. Terai region has largest portion of energy share from demand side followed nearby hilly region. Rural residential sector of Nepal highly compel to use fuel wood for cooking and heating purposes with more than 90% of share, hence fuel wood takes more than 95% of energy share in demand side consumption from base year to the end year.

3.1 Region wise Energy Demand

The central region is the largest energy consumer compared to other and energy consumption pattern seem very low in Western region.

3.2 Renewable Energy Technologies (RETs) Intervention Scenario

In RET scenario, the use of traditional fuel and imported fossil fuels are replaced by renewable energy technologies like electricity, solar, biogas or even bio briquette. Here share of fuel wood for its motive uses is being decreased to about 10% at the end year while the corresponding energy deficit is maintained by electricity, biomass and solar. The RET scenario is strategically planned to reduced fuel wood consumption by about 50% by year 2017 as suggested by the campaign through Government's policy and program unveiled by Rt. Hon'ble President in the parliament: "Every household in Nepal will be made Indoor Air Pollution Free bright household in next three years" (29 June 2014). Hence, the substituent fuel share must be enough to overcome such difficulties of energy deficit. In almost all cases, grid as well as micro-hydro electricity are assumed to fulfill the remaining energy demand.

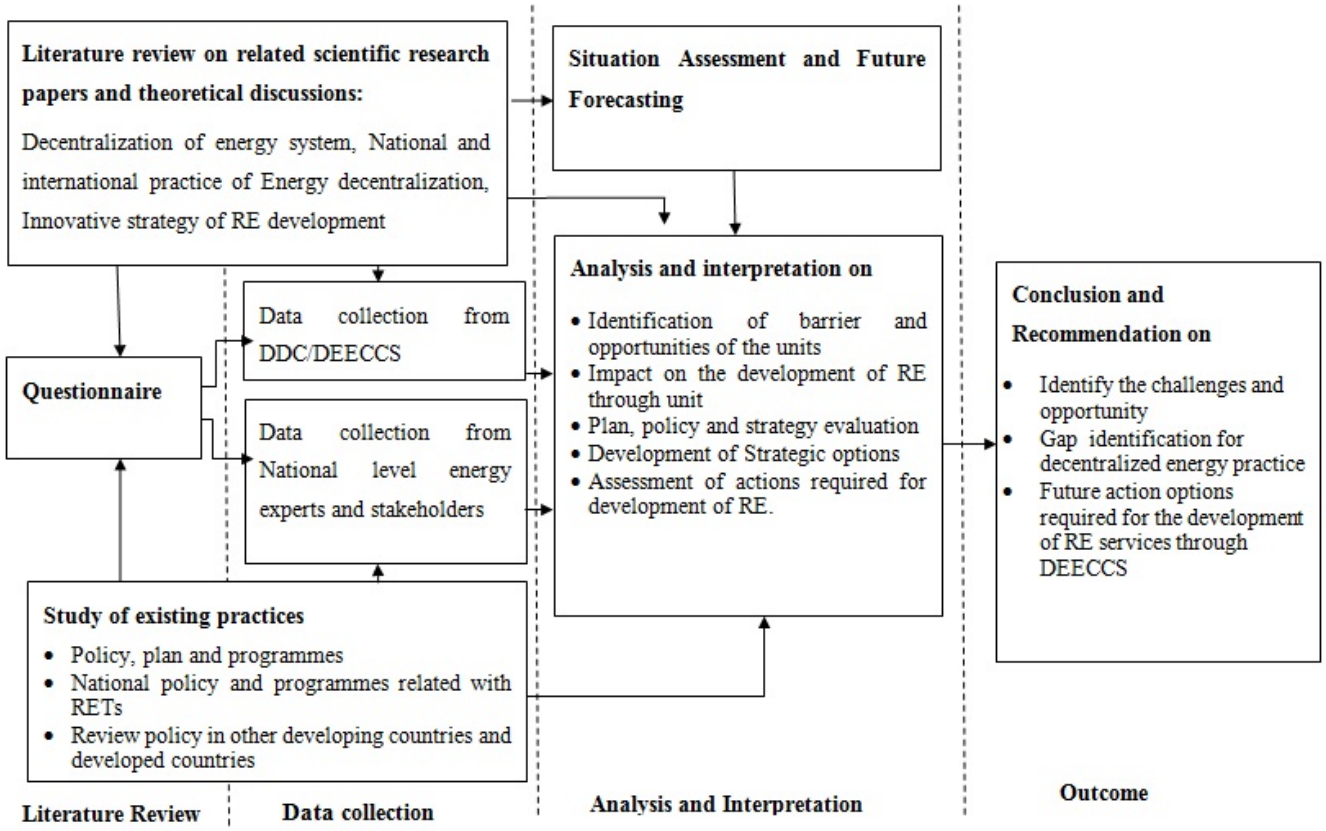

Figure 2: Research Framework for the Study

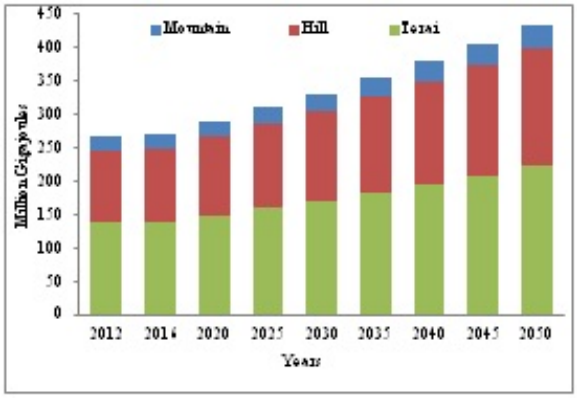

Figure 3: Ecological Belt wise Energy Demand

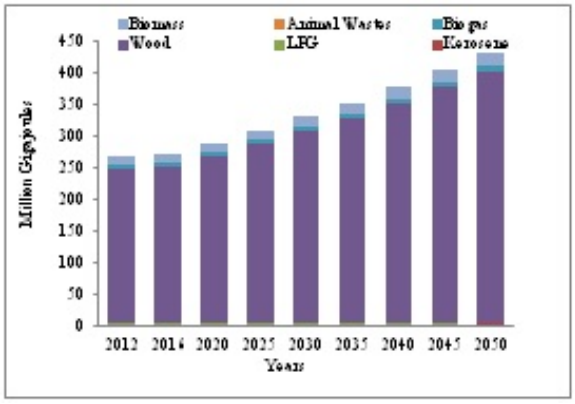

Figure 4: Fuel wise Energy Demand

3.3 Micro-hydro Promotion (MHP) Scenario

MHP scenario intends to promote micro hydro power and it's potentiality to additional support on national energy status. The scenario assumption of MHP with percentage profile from 2012 to 2050 is carried out. More specifically, to justify the scenario, the contributions of grid and off grid production are taken aggressively. The fuel wood share is being replaced by electricity to about 10% up to the end year while other renewable energy shares are play a constant role since they do not resides as a major attraction to this scenario. It seems that there is only tradeoff between fuel wood and the electricity in order to serve the rural residential energy demand from 2012 to 2050. Hilly region is most favored by CDR con-

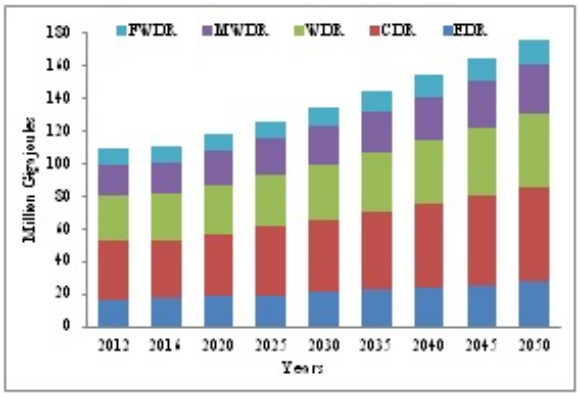

Figure 5: Region wise Energy Demand Hilly

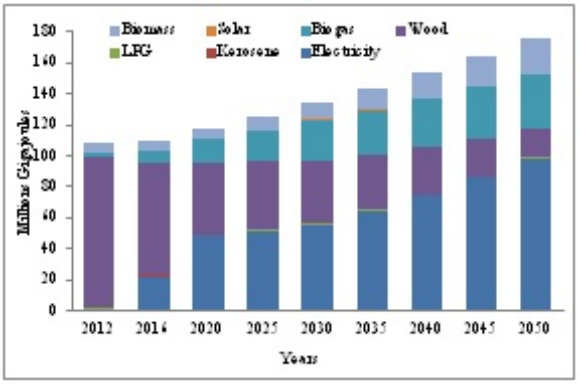

Figure 8: Fuel wise Energy Demand in Mountain

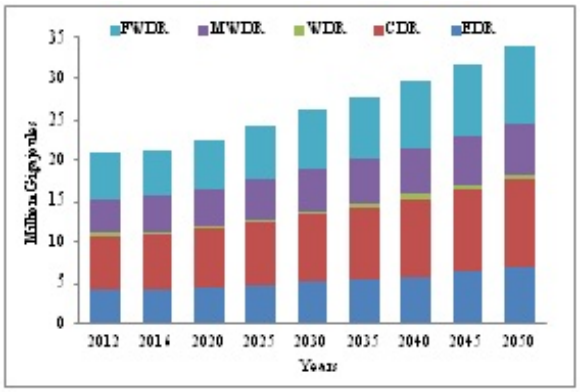

Figure 6: Region wise Energy Demand Mountain

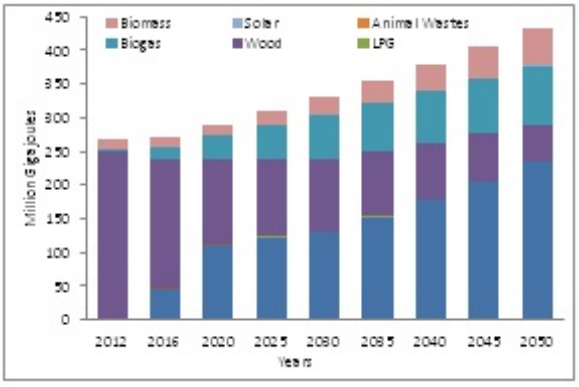

Figure 9: Fuel wise Energy Demand Hilly Region

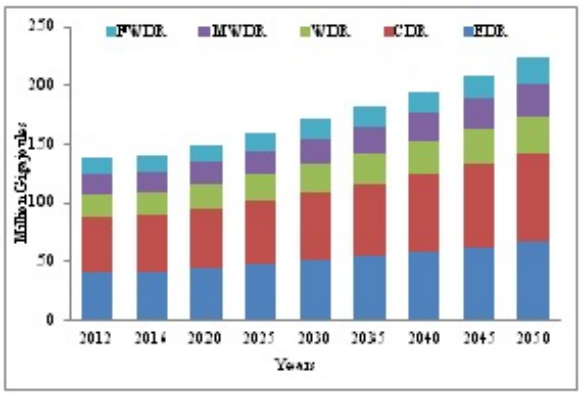

Figure 7: Region wise Energy Demand Terai

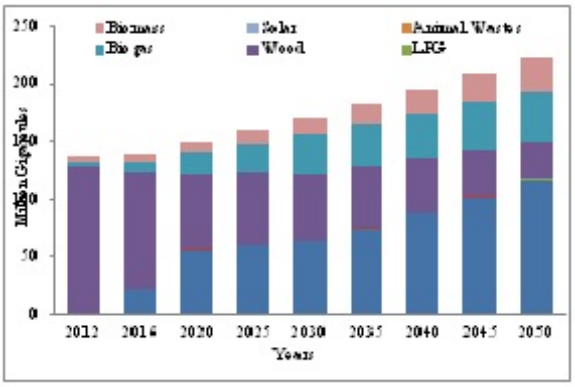

Figure 10: Fuel wise Energy Demand in Terai

tribution towards the energy consumption from the very start to the end. In total, Hilly region occupy the second position to demonstrate the energy consumption of rural residential sector. This starts from 108 million GJ in the base year to 176 million GJ to the end year projection. In the case of Terai region, it is an interesting that as it call for more energy more will be the energy starvation, which needs to be fulfilled with current energy production and supply system along with additional alternative measures. The base year energy consumption was found to be about 137 million GJ and the expectation with MHP scenario at 2050 is 223 million GJ.

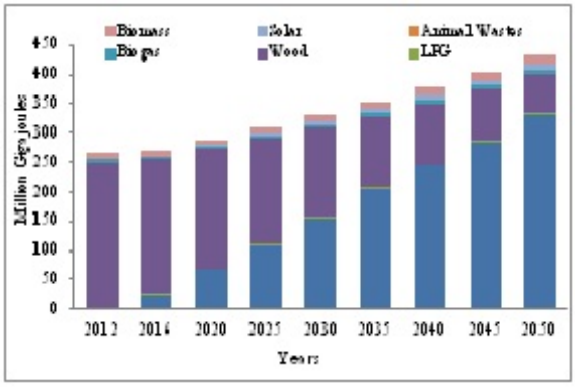

Figure 11: Fuel wise Energy Demand in Rural Residential Sector

Figure 14: Fuel wise Energy Demand in Terai

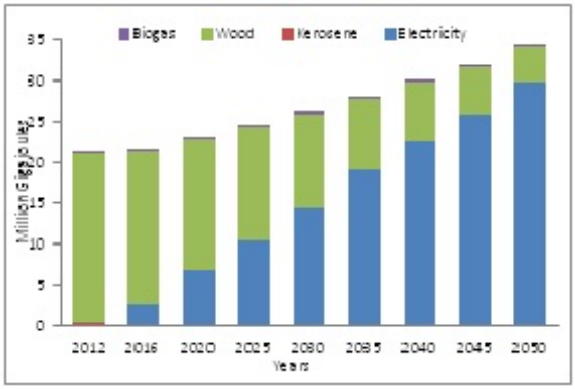

Figure 12: Fuel wise Energy Demand Mountain

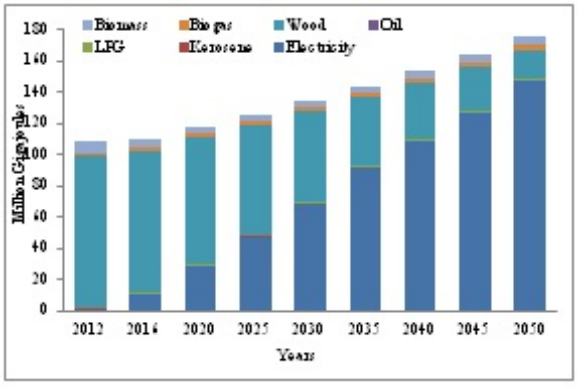

Figure 13: Fuel wise Energy Demand in Hilly

of growing rural residential energy demand. RET and MHP scenario are such scenario that helps to figure out those loopholes in policy mechanism in order to supply a sustainable power sources to fulfill the current energy demand and to track the future energy demand. The overall energy consumption of rural residential sector in 2012 is found to be 267 million GJ and is forecasted to be 433 million GJ to the end year; i.e. 2050. From following tabulated data shows that if the RET scenario is successful in implementing, renewable energy technology options are massive produced to assure the additional power from available resources that can be replenished and further utilized for the application of modern advanced technologies. Again, in MHP scenario the mini/micro/pico hydro power development should be carried out with 10% addition per year otherwise the energy supply and consumption could not be balanced in a single way. In MHP scenario, Mountain and Hilly rural part of Nepal could be taken as a major for hydro power generation and still there could be done in a better way to assist in adding extra power to national economy. The Comparative analysis of Energy Share in different Reference Scenarios is as shown in Table 1.

3.4 Scenario Comparison

While comparing all the scenarios in a single platform, we can make a conclusive decision that the rural residential energy demand is growing due to the population growth as well as with increasing in national GDP, economical activities. BAU scenario signifies the way

3.5 Output of Stakeholders Consultation

According to the discussion and the questionnaire survey form the district and national experts the following information are summarized.

Table 1: Comparative analysis of Energy Share in different Reference Scenarios

Units: Million Gigajoules	Scenarios											
	2012			2016			2025			2050		
Fuels	BAU	MHP	RETs	BAU	MHP	RETs	BAU	MHP	RETs	BAU	MHP	RETs
Electricity	1.1	1.1	1.1	1.1	34	66	1.2	107.9	121.7	1.4	332.2	234.7
Kerosene	0.8	0.8	0.8	0.8	0.7	0.6	0.9	0.6	0.5	1.3	0.8	0.5
LPG	1.5	1.5	1.5	1.6	1.6	1.2	1.7	1.7	1.1	2.4	2.4	1.5
Wood	246.3	246.3	246.3	259.8	228.9	174.5	285.4	180.3	114.9	399.1	63.8	52.7
Biogas	4.4	4.4	4.4	4.6	4.6	23.5	5	50.1	50	7.1	7	86.8
Animal Wastes	0.2	0.2	0.2	0.2	0.2	0.1	0.3	0.3	0.1	0.4	0.4	0.2
Solar	0	0	0	0	0.2	0.9	0	0.4	3.1	0	0.8	11.4
Biomass	13.2	13.2	13.2	13.9	12	15.2	15.3	11	21.1	21.4	15.4	56.1
Total	267.4	267.4	267.4	282.1	282.1	282.1	309.9	309.9	309.9	433.3	433.3	433.3

3.5.1 Existing Problem and Barriers in Units with Possible Solution

Table 2: Problems Vs Possible Solutions

SN	Problem and barriers	Possible solution
1	Limited clear policy, resources, authority, and units internalization	Formulation of policy and provision of additional support
2	Scatter of program from different organization	Decentralized program should be entered through VDC/DDC
3	Centralized subsidy delivery mechanism creates difficulty in coordination between PQ companies and communities	Subsidy delivery mechanism should flow through respective DDC

3.5.2 Challenges of DEECCS

According to the survey, the main challenging factors on the ingenious utilization of decentralized energy unit are the lack of proper institutional setup followed by the concrete policy for it. Whereas the resources limitation and internal capacity are ranked on the third and fourth position with the minimum influence on the development of decentralized energy practice.

Table 3: Ranking of challenging factor exist in the decentralized units

SN	Cirterion	Weights	Rank
1	Policy	25.5%	2
2	Institutional arrangement	36.8%	1
3	Internal capacity	15.5%	4
4	Resource limitation	17.9%	3
5	Others	4.2%	5

3.5.3 Capacity Development

The result shows that the technical skill development is very demanding in the units followed by the governance skill. The desire from DEECCS and suggestion from the experts on the area of capacity development needed are ranked and summarized as shown in Table 4.

Table 4: Ranking of challenging factor exist in the decentralized units

SN	Criterion	Weights	Rank
1	Technical Skill	37.3%	1
2	Social Mobilization Skill	16.6%	3
3	Governance Skill	30.3%	2
4	Leadership Skill	15.8%	4

3.5.4 Strategic Options

Renewable energy development at the local level should be strengthened by increasing the capacity of energy units, where supportive role can be provided by AEPC. The current rural energy subsidy policy is being criticized for not addressing the rural development needs and affordability of the rural population [5]. The improvement, specifically in achieving coherency in subsidy for various technological options and a close interdisciplinary coordination among different organization should be maintained in the development of energy sector. Resource mapping and techno-economical assessment in cluster level can be one of the ideas to find out the potentiality of renewable energy in each cluster. Different types of RETs can be implemented in those clusters, so the district wise prioritization of renewable energy resources are necessary.

3.5.5 Discussion on Finding

Decentralized energy delivery has the good potential to supplement the current centralized energy delivery system by strengthening the local bodies and making their active participation. So, there should be some incentive provision for local bodies. The establishment

of DEECCS in the district development committee had brought positive changes in the development of renewable energy and it integrates the RETs in DDC planning process. This study identified the challenges in terms of institutional arrangement and policy insufficiencies are equally presented by [6] and [7]. There is knowledge gap in the field of energy on the local bodies and communities. Capacity development is required in the field of technical skill about the renewable energy technologies along with the governance and social skill which have common suggestion from [8] and [9] that there is not expertise in all RETs by limited resources in DEECCS. The dispersion of subsides or other support should flow through district development committee is one of the result of this study that is equally suggested by the report [5].

4. Conclusions and Recommendations

4.1 Conclusion

The current pattern of energy development particularly focused on fossil fuels and centralized electricity which results in inequities of energy distribution and disregards the energy needs of rural areas. The knowledge gap in the field of energy is a major concern on the local bodies and communities. The present decentralized energy units in the district are facing different challenges. While ranking it, the institutional arrangement and policy lack comes in the first and second rank respectively. Adjoining these challenges the establishment of DEECCS in the district development committee had brought positive changes in the development of renewable energy linking with livelihood of rural people. Capacity development is required in the field of technical skill about the renewable energy technologies along with the governance and social skill for the effective and efficient promotion and development of renewable energy. Resource mapping and techno-economical assessment in cluster level is essential to find out the potentiality of renewable energy in each cluster. Here BAU scenario shows the growing rural residential energy demand forecasted up to 2050 without any policy intervention. The overall energy consumption of rural residential sector in 2012 is found to be 267 million GJ and is forecasted to be 433 million GJ by end year 2050. RETs intervention scenario demonstrate the massive development of renewable energy technology to fulfill the energy demands in different sectors like ecological and development region. It shows 60 percent of fuel wood will be replaced by RETs in year 2030 and 80 percent of fuel wood will be replace in year 2050 if this scenario are effectively implemented. Whereas MHP scenario shows the micro-hydro plant will be developed in massive way with 35 percent share of firewood in year 2035 and it will be 10 percent in the year 2050. So the district/cluster level prioritization and periodic target setting of renewable energy development are necessary. Moreover, the policy implication should be evaluated and justified by the proper economic and reliable mechanism for their techno-economic consideration with sufficient amount of investment.

4.2 Recommendation

Decentralized energy delivery has the huge potential to supplement the current energy crisis and to rural access of energy. It is impossible to reach rural household without good coordination with local agencies. For this bureaucracy system should be motivated by certain incentives and concrete policy towards it. Bottom-up approach is the key features of decentralized energy development and local resource utilization so the government and Ministry of Federal Affairs and Local Development should prepare a guideline for mandatory budgeting for the promotion of renewable energy. The decentralized energy units should be more responsible towards the district development committee and line ministry with supportive coordination with other stakeholders. The dispersion of any subsides or other additional support should flow through district development committee and necessary arrangement for it should be prepared by National Planning Commission, Ministry of Federal Affairs and Local Development, Alternative Energy Promotion Center.

Acknowledgments

The authors are grateful to Prof. Dr. Amrit Man Nakarmi, Dr. Shree Raj Shakya, Mr. Shree Krishna Khadka and all the Officers of sampled District Development Committee.

References

[1] National Planning Commission. *Three Year Plan*. Government of Nepal, 2011.

[2] International Energy Agency. World energy outlook. Technical report, IEA, 2011.

[3] *Local Self Governance Act*. Ministry of Local Development, 1999.

[4] Water and Energy Commission Secretariat. National survey of energy consumption and supply situation in nepal. •.

[5] Practical Action. Study to determine outline plans for eliminating energy proverty in nepal. Technical report, Practical Action, 2009.

[6] Zereay Tessema. Mainstreaming sustainable energy access in the development planning process of ethiopia. Master's thesis, KTH School of Industrial Engineering and Management, 2012.

[7] Surendra K.C.; Samir Kumar Khanal ; Prachand Shrestha ; Buddhi Lamsal. Current status of renewable energy in nepal: Opportunities and challenges. *Science Direct*, 2011.

[8] Elisabeth Clemens; Kamal Rijal; Minoru Takada. Capacity development for scaling up decentralized energy access programmes. Technical report, United Nations Development Programme, 2010.

[9] Multiscope Consultancy Pvt. Ltd. Feasibility study of energy hubs for aepc. Technical report, Alternative Energy Promotion Center, 2014.

[10] Sudeshna Banerjee; Avjeet Singh ; Hussain Samad. Power and people, the benefits of renewable energy in nepal. Technical report, The World Bank, 2010.

[11] Bandi Venkata. Decentralized energy services delivery in developing countries. Technical report, 2010.