Grid Extension in Countries of Power Shortages

Experience from Energising Development (EnDev), Nepal

giz

Prepared by GIZ-EnDev, July 2011

Contents

List of Abbreviations

CREE	Community Rural Electrification Entity
CREP	Community Rural Electrification Programme
EnDev	Energising Development
GDP	Gross Domestic Product
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GWh	Gigawatt hour
HH	Household
kV	Kilovolt
kWh	Kilowatt hour
MW	Megawatt
NACEUN	National Association of Electricity Users Nepal
NEA	Nepal Electricity Authority
NPR	Nepalese Rupee
PPP	Public Private Partnership

1 Introduction

Many developing countries suffer from power shortages, especially in fast growing economies, where electricity demand raises sharply. The electricity sector is in most cases unable to keep up with the pace of development as governmental regulations are inadequate, national utilities perform poor and/or insufficient capital hinders the implementation of new projects. At the same time, significant parts of the rural population are excluded from power supply, due to high investment and administration costs and limited purchasing power. Nevertheless, grid extension to rural areas is still one major development focus of most electricity utilities in developing countries. However, increasing the number of customers and thus overall electricity demand seems to contradict with the aim to overcome power shortages.

In general the delivery of electricity to the customer consists of three independent parts, namely generation, transmission and distribution. After generation electricity needs to be transmitted to areas with high demand. An elaborated network of transmission lines is essential, especially if electricity is generated far from areas of major demand. Close to the end-user, electricity is transformed to low-voltage so that it can be distributed to households and commercial users. Consequently, power shortages can be caused by insufficient capacities in one or more of the three independent stages of electricity supply.

The following paper will examine the independencies between power shortages and the governmental Community Rural Electrification Program (CREP) in Nepal. One of the central questions is how far grid extension to rural areas affects the overall electricity supply and if it opposes efforts to overcome the national power shortage. Furthermore, it is questioned how far rural communities are affected by the power shortage and how far newly connected users are satisfied with the quality of supply. Especially the relation between power cuts and customer satisfaction is crucial to answer how far grid extension is reasonable even when massive power cuts for newly connected users are expected.

The first part focuses on the electricity sector in Nepal, examines the reasons for power shortages and tries to give an outlook on how power demand and supply will develop within the next 10 years. On the basis of experience from 13 electrified villages the second part will answer how far rural communities are affected by power shortages in reality and whether the situation in the villages corresponds with the picture drawn in the previous chapter. Subchapters will focus in addition on the question how far customer satisfaction is affected by the extent of load-shedding and how rural HH cope with the regular power cuts. Finally, findings are summarized in the last chapter.

2 Electricity Sector Nepal

2.1 Demand, Generation & Installed Capacity

The Nepalese Electricity Authority (NEA) as the major state-owned electricity utility faces an immense increase in electricity demand, whereas at the same time production and transmission capacities are limited. Though, ambitious development targets are announced by politics, the development of plants and transmission lines cannot keep up with economic development and its induced demand increase.

Between 2001 and 2010 peak demand has more than doubled from 391 to 885 MW. In the same period of time annual electricity production increased from 1868 GWh to 3689 GWh. Production is heavily dependent on hydropower, as 83 % of the total electricity was generated by either NEA-owned or private hydropower plants in 2010.

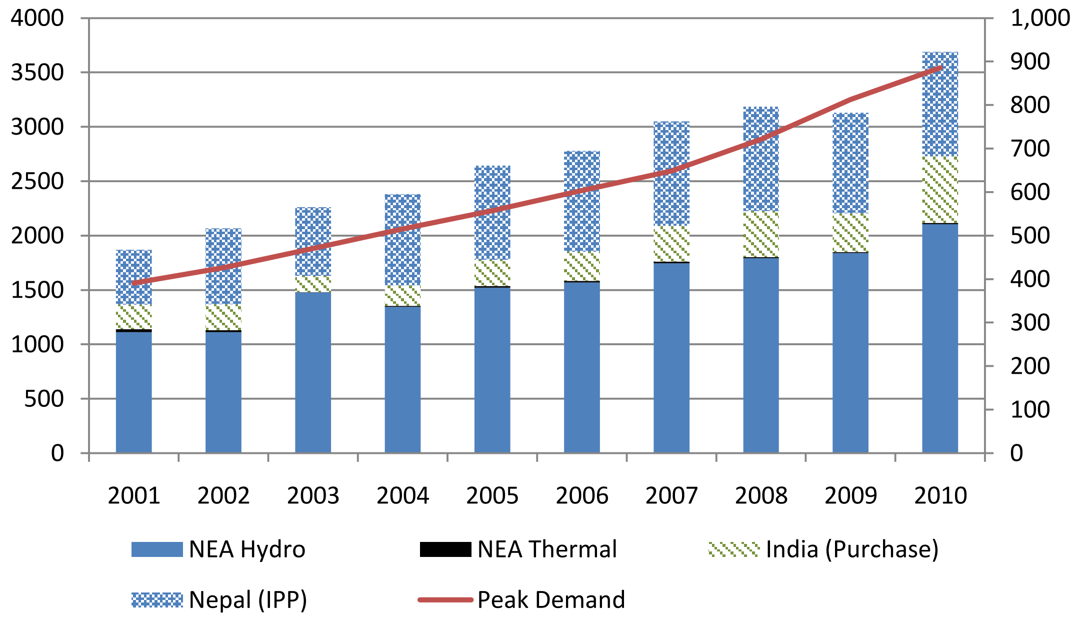

Figure 1: Electricity Generation in GWh and Peak Demand in MW (2001 - 2010)

Source: NEA 2011

In order to meet the growing hunger for more electricity, imports from India have become more important during the last decade. In 2010 they accounted for 16.6 % of total energy production. Whereas private and state-owned hydropower generation has doubled in the last ten years, power imports from India almost tripled (from 266 GWh in 2001 to 612 GWh in 2010). Contributing only 0.4 % to the overall generation, thermal generation plays a negligibly small role in Nepal. (NEA 2011)

A similar picture can be drawn in terms of installed generation capacity. Currently, 644 out of 697 MW installed capacity is hydropower. Around 517 MW (74 %) of hydropower capacity is NEA-owned, while 166 MW (26 %) is privately owned and operated. Due to rising fuel prices two diesel power plants with a total installed capacity of 53.4 MW were almost abandoned within the last years. Figure 2 gives a comprehensive overview on the installed capacity by fuel type. (NEA 2011)

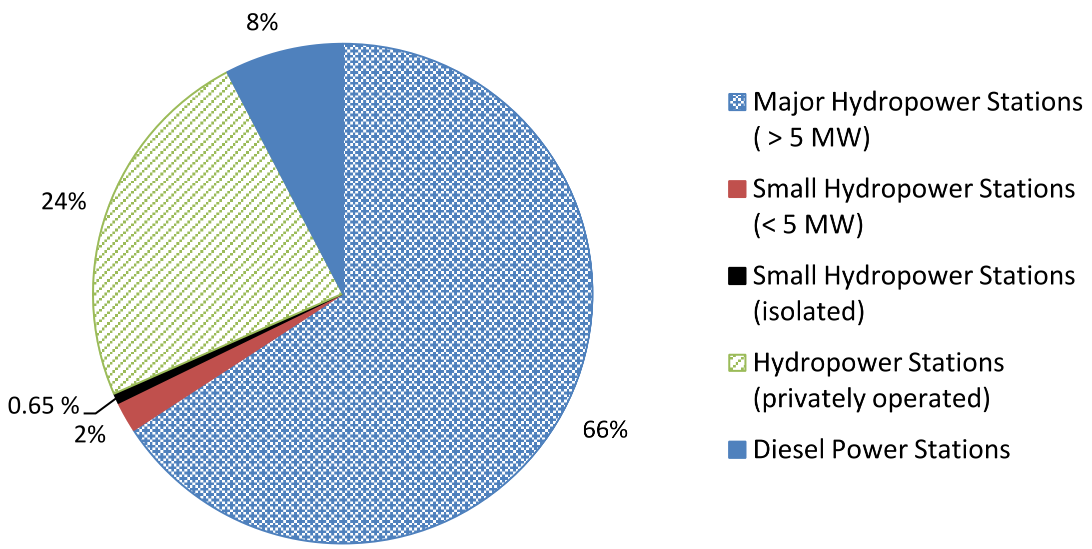

Figure 2: Type of Generation among installed capacity (2010)

Source: NEA 2011

2.2 Regional Disparities

In 2008/09 consumption of electricity was almost balanced between industrial (manufacturing) sector (37.37 %) and households (45.52 %), while the commercial sector[1] consumed only 6.6 %. (MoF 2010) However, the industrialized and urban areas account for the majority of electricity demand. Around 28 % of electricity produced in Nepal in the year 2005 was consumed in the Kathmandu Valley alone. (Shrestha 2010) The vast majority of electricity is currently consumed in the central and eastern region. Therefore an elaborated system of transmission lines is required as few hydropower plants are situated close to areas of high demand. Middle- (70 MW), Lower-Marshyangdi (69 MW) as well as Kali-Gandaki A (144 MW) as the biggest hydropower projects are all situated in the western part of the country. At the same time, this power cannot be transmitted to the central and eastern part due to bottlenecks in the transmission network between Bharatpur – Hetauda – Dhalkebar. Especially the eastern region has become totally dependent on power imported from India. (The Kathmandu Post 2011b) Besides low generation capacity, the poor transmission network seems to be the major bottleneck in the Nepalese electricity sector.

2.3 Power Shortage & Load-Shedding

The general shortage of electricity is manifesting itself in scheduled power cuts (so-called load-shedding), which became an incremental part of power supply in Nepal within the last years. Especially during dry-season Nepal's dependence on hydropower becomes obvious, forcing the NEA to cut power in Kathmandu up to 16 hours per day (as in April 2011). The situation has even worsened as only two hydropower plants with an installed capacity of 92 MW are storage types, while the rest are run-off river plants (WECS 2010).

Figure 3 illustrates the growing gap between electricity demand and supply and corresponds with the appearance of load-shedding. Since 2006/07 the supply gap increased from 105 GWh to 678 GWh in 2009/10, with the temporary peak in 2008/09 with 745 GWh. Furthermore, the figure shows the seasonal fluctuations due to irregular run-off rivers. Due to glacier melt and intensive rainfall during the monsoon season, electricity supply almost matches the demand between June

[1] Defined as all firms that are not engaged in farming, manufacturing, or transportation.

and October. However, during the winter (where precipitation is far less) generation capacity decreases along with diminishing run-off rivers.

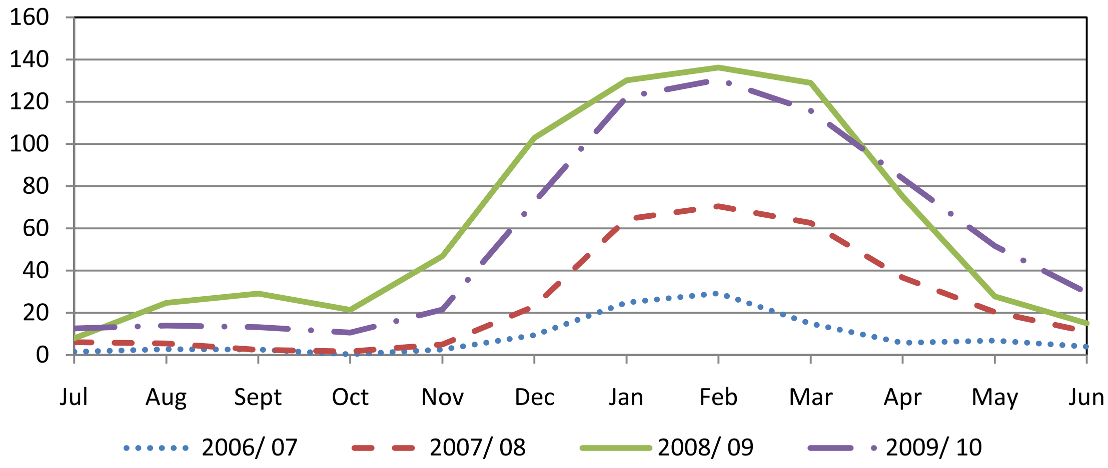

Figure 3: Electricity Supply & Demand Gap in GWh (2006 – 2010)

Source: NEA 2011

Coping with load-shedding is challenging both the industrial and commercial sector. Despite preferential treatment of the industrial sector (which is partly spared from load-shedding), manufacturing suffers hard from the power crisis. Newspapers report, that manufacturing industries have to cut their production between 25 and 80 % in peak times. Small commercial businesses are similarly affected by load-shedding, as many are dependent on power and are thus forced to use generators or backup systems. (The Kathmandu Post 2010, 2011a) The long-term impact of poor power supply is observable as the share of manufacturing sector among GDP declined from 9 to 6 % since 2000/01. (Himalayan Times 2011)

2.4 Demand Forecast & Outlook

According to estimations of the NEA energy demand will grow in the next 17 years with an average annual rate of 8.34 %. The current demand of 4430 GWh annually is expected to double until 2018 and exceed 17,400 GWh by 2027. Along with the growing demand it is projected that system peak load will increase with similar annual growth rates, reaching 3679 MW in 2027. (NEA 2011)

These estimations require an immense increase in the exploitation of the vast hydropower resources in Nepal. Of the 42,000 MW of economically feasible hydropower resources only the relatively small share of 1.7 % is tapped. (WECS 2010) Despite long term development plans targeting to reach 10,000 MW of installed capacity by 2020 (according to the 10-years hydropower development plan), current development of the sector draw a rather different picture.

Currently, projects with a total capacity of 547 MW are under construction. NEA projects account for the major share (500 MW) of it. Planned and proposed projects would furthermore increase the capacity by 1422 MW. But considering the relatively slow deployment of new projects in Nepal, it seems unlikely that until 2020 more than 7000 MW of capacity will be contributed by projects that even have not been proposed until now.

Though, actions to upgrade generation capacity within the next ten years were taken, the current situation of load-shedding is likely to persist and may even get worse in the near future. Chamelia and Kulekhani-III with a capacity of 30 and 14 MW respectively are expected to be completed in 2011. However, the first one is situated in the Far-Western region and is thus unable to contribute to the major demand in the central and eastern part of the country. If at all, relief can be expected when the Upper Tamakoshi project is connected to the national grid. With a total capacity of 456 MW it is expected to contribute 2281.2 GWh annually. Developed as a PPP it is scheduled to start production in 2013/14. (NEA 2011) Considering the estimated growth of energy demand, capacity will hardly meet peak demand even after completion of the three above mentioned projects. Especially, in the dry seasons plants will operate far below their maximum capacity, resulting in load-shedding or an immense increase of power imports from India.

As all projects that are currently under construction are run-off-river types, the Nepalese power sector will be even more dependent on seasonal fluctuations of river flows. Furthermore, it is unclear how climate change will affect water security in Nepal. Linked to many uncertainties, climate change affects run-off rivers by (a) glacier retreat and (b) changes in rainfall intensity and patterns. Projections estimate that run-off could be reduced by 14 % due to climate change, reducing both generation capacity and economically feasible hydropower potential. (Pathak 2010)

3 Rural Electrification in Nepal

3.1 Rural Electrification & EnDev Activities

Initiated by the Government of Nepal, the National Energy Authority (NEA) launched in 2003/04 the Community Rural Electrification Program (CREP) with the aim to connect rural communities to the national grid. Costs for grid extension are predominantly covered by the government through the NEA (80 %). The communities have to cover the remaining 20 % by own contributions. Once connected to the grid, the NEA sells bulk power to the so-called Community Rural Electrification Entities (CREE). Those organizations founded by the communities are responsible for the local operation and management of the electrification including collection of revenues from villagers and payment for bulk power purchased from NEA.

The Dutch-German Energy Partnership Energising Development (EnDev), implemented by GIZ, started its support of the Community Rural Electrification Program in 2008. The overall aim to provide access to modern energy services for rural households through extension of the national grid is realized by providing organisational, financial as well as technical support to those CREEs that face problems in providing their financial contribution. Whereas the whole program covers more than 200 communities, EnDev concentrates on 49 CREEs.

Figure 4: Distribution of EnDev supported CREEs

Up to May 2011, 14 CREEs were covered by verification visits. In the course of household surveys data on consumption patterns, quality of installations and customer satisfaction was collected. Following chapter is predominantly based on findings of the first 10 verification visits and an interview with the National Umbrella Organization of CREEs (NACEUN) carried out in April 2011.

3.2 HH Consumption

Most HHs in rural areas have a very low electricity consumption, as in most cases electricity is only used for lighting, radios and mobile chargers. Average monthly consumption ranges from 17.8 to 33.4 kWh, whereas the average HH consumes 25 kWh monthly (according to the data collected during the first ten verification visits). Considering that on average 6.19 persons live in one HH, per capita consumption is far below national average (which is 15 kWh per month and capita). Based on the average HH consumption it can be estimated that all 49 EnDev Nepal supported communities will consume 15.9 GWh annually. Comparing this number to the overall annual electricity consumption[2], EnDev activities would increase the national power consumption by 0.59 %. All with EnDev Support electrified HHs would account in this scenario for 2.98 % of all electrified domestic HHs in Nepal.

According to NACEUN estimations all under the CREP electrified communities (in total 116) consume 27.4 GWh annually, which accounts for 1 % of the overall annual electricity sale in 2010. As currently 6.18 % of all electrified HHs are connected to CREEs, the annual consumption of all CREEs is still relatively low. Considering that national demand was growing annually in the last decade between 7.5 % and 12.5 % (35 and 90 MW respectively), the impact of the CREP on the national electricity demand is negligible small.

3.3 Load-Shedding in CREEs

Depending on the geographical location of the CREE, communities face very different load-shedding schedules. Except two CREEs, rural areas seem to be less affected by load-shedding compared to Kathmandu. The map below is indicating in which districts hours of load-shedding were less than in Kathmandu (marked green) at the time of the verification visits. Districts that

[2] Equal to total electricity sale in 2010 which was 2677.83 GWh (NEA 2011)

were heavier affected by load-shedding than Kathmandu are marked red, while district affected by load-shedding to the same extend as the capital are yellow.

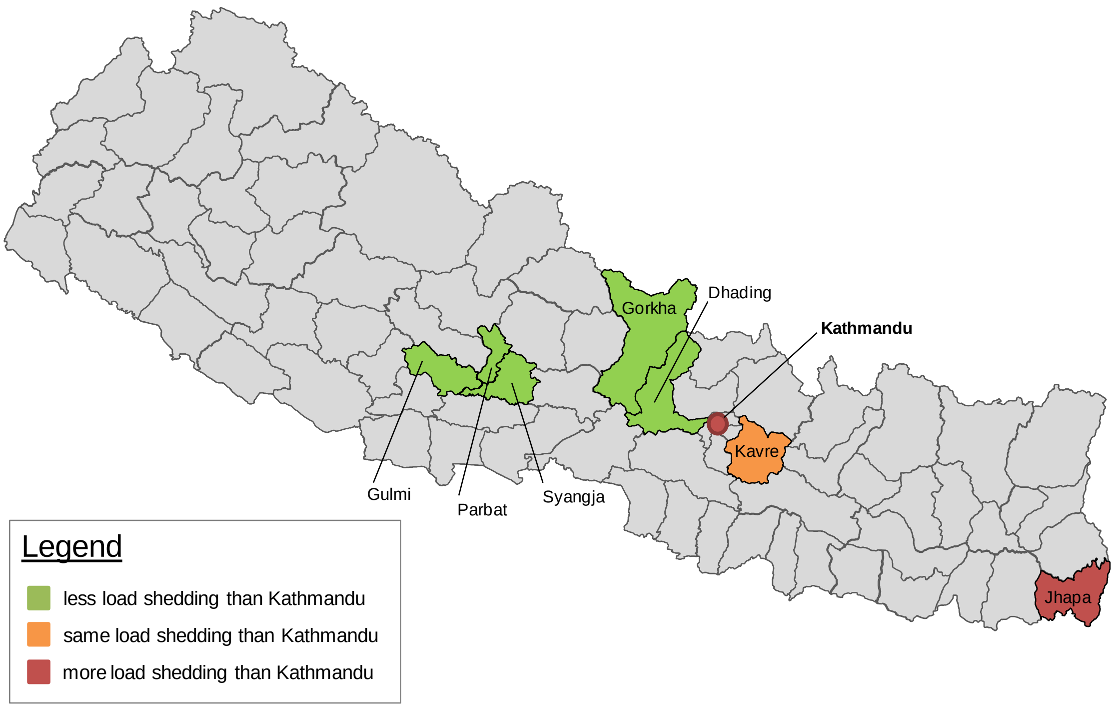

Figure 5: Hours of Load-Shedding in districts covered by EnDev in comparison to Kathmandu

However, the data used for this map was collected in several months, making a comparison between districts difficult. In addition, the data is influenced by non-scheduled power cuts, which are often perceived as load-shedding by customers (due to insufficient information). During the first verification visit in April 2010 one CREE in Syangja district had on hour less daily power cuts than Kathmandu, whereas at the same time one CREE in Jhapa was affected by 4 hours more daily power cuts than the capital. One CREE in Kavre district visited in May 2010 was affected from load-shedding to the same extent as the capital (12 hours). Another CREE in Gulmi district visited in June 2010 was only affected by 1 hour-lasting daily power cuts, whereas in Kathmandu electricity was not available for 5 hours. Four CREEs in Parbat and Gorkha district visited in December 2010 faced only 1 and 2 hours of power cuts respectively, whereas Kathmandu experienced cuts up to 8 hours daily. In March 2011, one CREE in Jhapa was affected by 14 hours of daily power cuts (same as Kathmandu), whereas at the same time two CREEs in Dhading and Syangja districts were only lightly affected by 1 and 0.7 hours of load-shedding daily. Apparently, districts located in the western region are less affected by load-shedding than districts in the central and eastern part of the country. The table below gives an overview on hours when electricity was available during the survey and the corresponding load-shedding in Kathmandu.

Name of CREE	District	Date of Verification Visit	Load-Shedding per day (hrs.)	Load-Shedding per day in Kathmandu (hrs.)
Samudaik Sewa Kendra Jilla Samanwaya Samitee	Syangja	Apr 2010	10	12
Parijat Sahakari Sanstha Ltd.	Jhapa	Apr 2010	16	12
Gaun Samaj Bidhutikaran Bikash Ka Lagi Samuhik Abhiyan	Kavre	May 2010	12	12
Wami Samudaik Gramin Vidyut Upabhokta Samitee	Gulmi	Jun 2010	1	5
Gramin Samaj Bikas Samudayik Sanstha	Banke	Oct 2010	1	4
Ringneraha Purbakhola Samudayik Bidhut Bitarak Sanstha	Ringneraha	Sept 2010	0	4
Paiyun Chhetra Gramin Bidhutikaran Upabhokta Samiti	Parbat	Dec 2010	1	8
Ghyampeshal Samudayik Bikash Kendra, Masel	Gorkha	Dec 2010	2	8
Ranipani Samudayik Gramin Bidhutikaran Upabhokta Samiti	Parbat	Dec 2010	1	8
Bahakithati Samudayik Bidhutikaran Upabhokta Samiti	Parbat	Dec 2010	1	8
Sanakisan Sahakari Sanstha Ltd.	Jhapa	Mar 2011	14	14
Maidi Gramin Bidhut Sahakari Sanstha	Dhading	Mar 2011	1	14
Okobara Samudaik Vidyut Upabhokta Samitee	Syangja	Mar 2011	1	14

Table 1: Load-Shedding in CREEs compared to Kathmandu

Explanations for the availability of electricity in rural communities are manifold and differ from case to case. Many small and major hydropower plants are located in the western region and capacities to transmit power to areas of high demand (e.g. Kathmandu Valley and eastern Terai) are limited. In addition, Hydropower plants below 5 MW capacity are seldom connected to the Integrated Nepal Power System which is supplying areas of major power demand. In fact, smaller hydropower plants mainly supply surrounding area with electricity via 11 or 33 kV lines.

In another case, one CREE in Banke district is supplied by an indo-nepali hydropower joint venture which is located in India but supplies a certain amount of electricity to Nepal. There is a clear tendency that areas close to the Indian border which are supplied from their neighbour country (either by indo-nepali joint ventures or purely Indian plants) have a more regular power-supply and are less affected by load-shedding. However, exceptions exist in areas where demand exceeds electricity imports as it is observable in the eastern Terai.

But not in all cases a purely technical explanation is suitable, as load-shedding is also used as selective political measure. During a verification visit in March 2011 in Dhading and Syangja, representatives from the CREEs stated that the NEA wants to avoid conflicts with people from areas where hydropower projects are situated or going to be constructed. Therefore, local communities surrounded by huge hydropower plants are normally connected directly via 11 kV lines with the plant and are completely or partly spared from load-shedding in order to retain the social harmony. NEA officials fear otherwise the blockage and shut-down of existing plants or massive protests against new projects. This explanation is not only valid to certain projects. It can be furthermore seen as a general NEA guideline applicable to the whole country.

3.4 Customer Satisfaction

Rural electrification via grid extension influences not only the national power demand. Customers are vice versa affected by the power shortage in the form of load-shedding. From the beginning of the electrification process rural HHs are involved in the financing of the communities share, paying for the final connection of the house and last but not least paying their monthly bills. Those expenditures account normally for a considerable amount of the HH income. The reliability of the power supply could be consequently one major determinant for customer satisfaction.

In general, CREE customers seem to be satisfied with the quality of electricity supply. 91.2 % and 90 % of all HHs stated to be satisfied with the quality and costs of electricity supply respectively. Surprisingly, customer satisfaction does not correlate negatively with load-shedding hours. With 20 % of unsatisfied customers the CREE Ghyampeshal Samudayik Bikash Kendra, Masel, Gorkha was the most unsatisfied CREE, though only affected by 2 hours of load-shedding in December 2010. Moreover, customer satisfaction seems to be determined by local service quality and by unregularly and not announced power cuts. People are somehow accustomed to load-shedding for many years as it also gains much attention in media and public discussions. In contrast to the expected regular load-shedding, especially the quality of supply (voltage drops, irregular power supply) seems to determine the satisfaction to a greater extent.

3.5 Coping with Power Cuts on HH Level

In the course of two verification visits in March 2011 data on sources and expenses of lighting during load-shedding hours was collected. In one CREE in Jhapa district where 14 hours of load-shedding was reported during the survey, the average HH spent 88 NPR on alternative energy sources per month. Compared to the average monthly electricity bill of 147 NPR the amount spent on energy sources during load-shedding is considerable. Among 40 interviewed households the majority (30 HH and 75 % respectively) uses kerosene during load-shedding hours, while two households rely on candles and kerosene. Besides this three households own a Solar Home System, four a charging light and one household an inverter system. Once invested in a solar or inverter system running costs are comparable low and are therefore ignored in the calculation of average monthly spending.

In one CREE in Dhading district, which was only affected by one hour of daily load-shedding the average households spent 23 NPR per month on alternative sources (while the average HH pays 100 NPR for electricity per month). 27 out of 60 households (45 %) use kerosene as main source, while only one household uses torches and has to buy therefore batteries. 32 households (53 %) do not have any running expenses for alternative lighting sources since they use either solar systems (18 HHs), charging lights (13 HHs) or firewood (1 HH).

Those findings highlight that expenses for alternative energy sources during load-shedding account for a significant share of total energy costs (considering that most households pay the monthly minimum electricity charge of 80 NPR per month). However, households still seem to be satisfied with electricity supply, as costs are lower and quality of lighting is better.

4 Conclusion

The Nepalese electricity sector is currently struggling with low generation capacity and a poor transmission network, resulting in long and frequent power cuts in areas of high demand. At the same time the government is promoting grid extension to rural areas in order to alleviate rural-urban discrepancies, vitalizing rural economies and lift the rural population's living standard. Although, there seems to be an obvious contradiction in these policies, the situation in Nepal is far too complex to draw any quick conclusions.

First of all, rural communities account for an insignificant share of national electricity demand. Estimations from NACEUN underline this point as demand from 116 CREEs account for 1 % of the overall national power consumption. In line with this, projections show that all EnDev supported communities are expected to consume 0.59 % of the country's current annual electricity consumption.

Second, the majority of CREEs seem to be less affected by load-shedding, suggesting that power shortages in most rural areas are less substantial. Especially in the western region, where the majority of hydropower capacity is installed, CREEs tend to suffer less from power cuts. In some cases, the rural communities are supplied by small hydropower plants, which are normally not connected to the Integrated Nepal Power System, and are thus supplying surrounding areas with electricity. In other cases, neighbouring communities are connected with medium voltage lines to huge hydropower projects. As a selective political measure areas where hydropower projects are hosted or under construction are often (partly) spared from load-shedding. The NEA favours concerned areas in order to avoid social conflicts that could culminate in a shut-down of existing plants or delays in construction of new projects.

Customer satisfaction seems to be not affected by load-shedding, as in all CREEs more than 80% of customers are satisfied with the electricity supply. Even in those communities that are heavily hit by power cuts, the vast majority is content. This suggests that grid extension is desired by local communities, even though they expect to be affected by load-shedding.

In conclusion, the case of Nepal highlights, that there is no real trade-off between rural electrification and efforts to overcome the national power shortage. The limitations of the transmission network give space to provide electricity access to rural households by increasing the load factor of plants that are not connected to the Integrated Nepal Power System. On the other hand, communities - located in areas with no hydropower projects - compete with urban areas for scarce electricity supplied by the transmission network. However, EnDev supported communities are mostly situated in the western part of the country (41 out of 49 communities), so that the impact on the electricity supply in region of massive shortages is minimal.

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