Application of Clean Energy in Nepal:Prospects and Problems

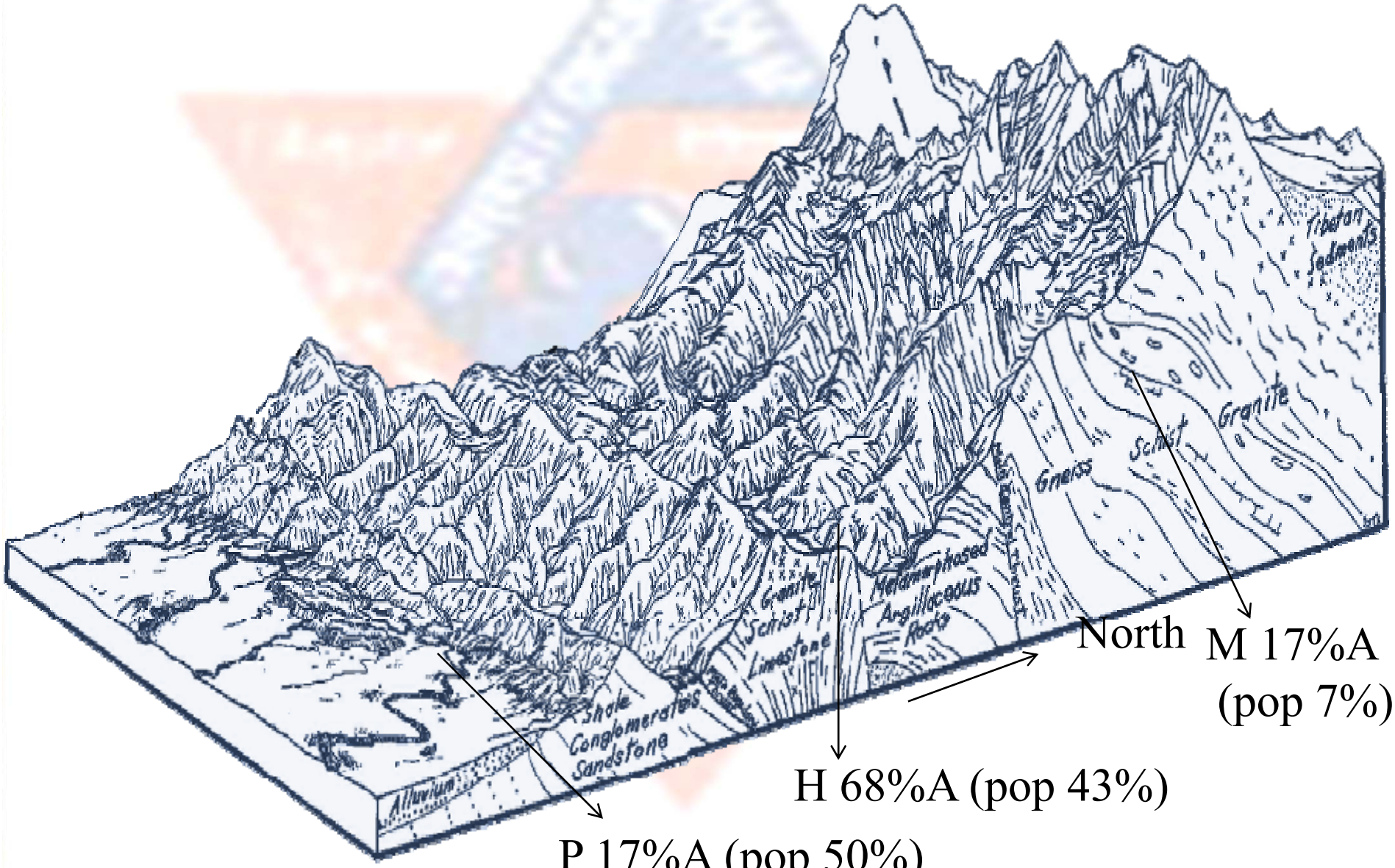
Dr. Jagan Nath Shrestha
President, Nepal Solar Energy Society
Visiting Professor, Center for Energy Studies,
Institute of Engineering, Tribhuvan University

SAR/StANCE Meeting
10 November 2014
Kathmandu

Geography of Nepal

Population:26.4 Million (2011 Census)

Area: 147,182 km2; Pop. Density:180/km2. HH Sise:4.88



Natural Energy Resource Base of Nepal

- **About 6,000 rivers, with h a total length of about 45,000 km with an annual discharge of 200 billion cubic meters of water are available in the country**
- **The commercial potential of hydro-power in Nepal is said to be about 42,000 MW, may be 150 MW if cascading is considered**
- **So far only about 712 MW (Hydro) have been connected to peak load system, which constitute about 2% of total energy supply**
- **Forests supply nearly 78 % of the total energy requirement of the country, and also provide 50% of fodder for livestock purpose.**
- ***On average Nepal has 6.8 sunshine hours per day, i.e. 2,482 sunshine hours per year with the intensity of solar insolation ranging from 3.9 to 5.1 kWh/m2/day. (National average is about 4.7 kWh/m2/day.)***
- **Though significant wind potential is noted to be available in mountainous region (Mustang district, Khumbu region, Palpa, Ramechhap, Karnali Chisapani, Jumla) no proper wind mapping of Nepal has been done so far.**

History of Load Shedding in Nepal

Year	Max Load Shedding during dry season
2020 BS/1964	Low Voltage (around 140 VAC during evening hours)
2057 BS/2000	Heavy Load shedding
2062 BS/2005	2 hours/day
2063 BS	3 hours/day
2064 BS	8 hours/day
2065 BS	16 hours/day (expected 9 hours/day)
2066 BS/2009	**18 hours/day**
2067 BS	14 hours/day
2068 BS	12 hours/day
2069 BS/**2012**	10 hours/day (as of 2069.8.9 **(9 Dec 2012)**
2070 BS/Jan 2014	**12 hours/day (as of 2070.09.21 (5 Jan 2014)**
2071 BS/June 2014	**8 hours/day (as of 2071.02.21 (4 June 2014)**

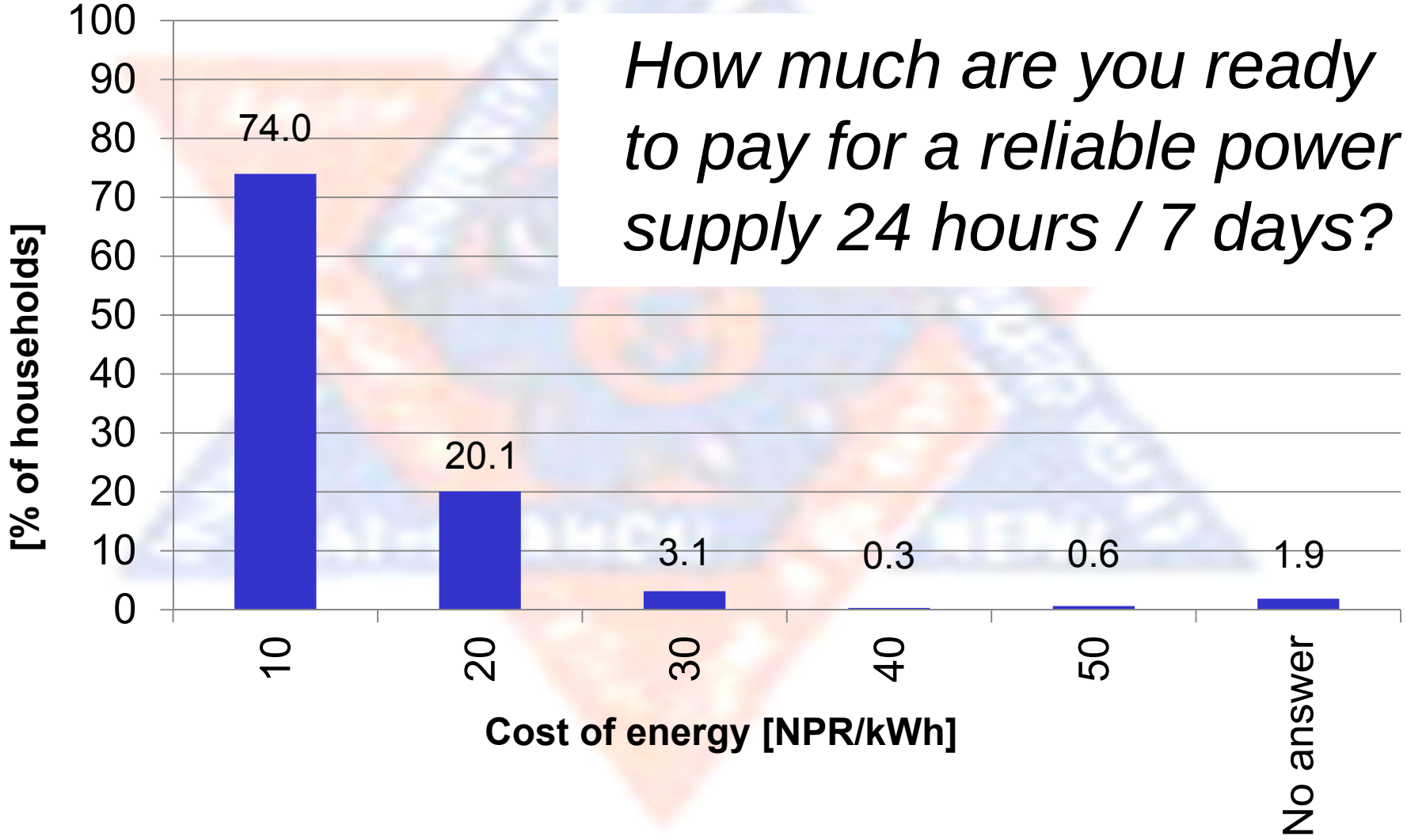
(Source: LDC/NEA; SUPSI/CES/IOE; Nagrik, 2069/5/8 i.e. 24 Aug 2012 for data from 2066 BS to 2069,5.8)) , newspapers of different dates

Load shedding disturbance:

1. Disturbance on **education** and **study** 90.6%
2. Disturbance on **water supply** 56.1%
3. Loss of work capacity and income 31.7%
4. Difficulties in food storage 29.8%
5. Disturbance on social activities 27.0%
6. Health hazards 19.4%
7. Others 7.2%

Source: CES/SUPSI Study 2009/10

Willingness to pay



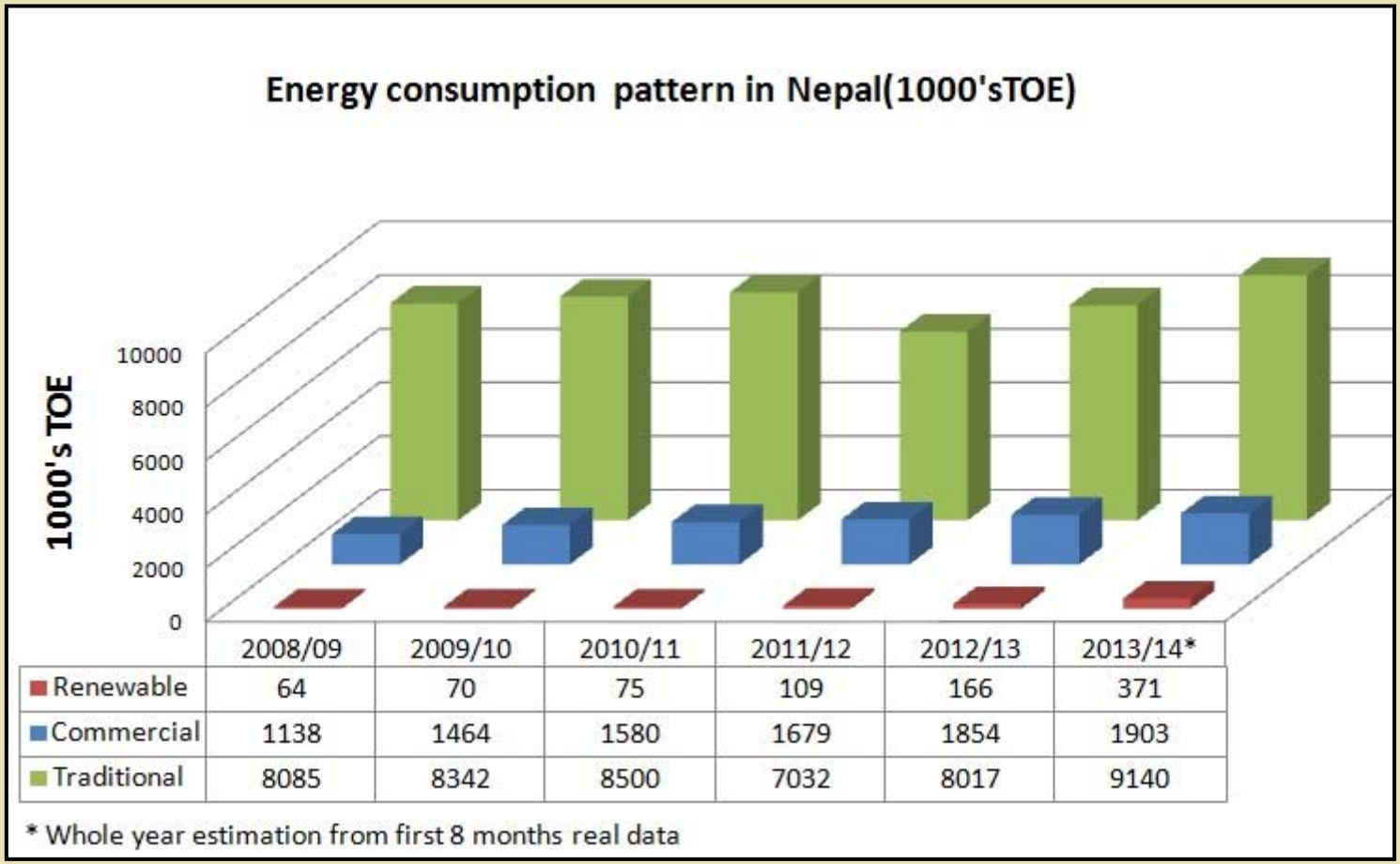
Diesel Based Captive Power

More than 700 MVA DG sets as of Dec 2013 (CES/IOE Study)

Loss of Rs. 64 Million/month (Rs.64Crore/month) (Source: NOC, 44 th NOC Anniverssary Function, 10 Jan 2014)

Expenditures: Nepal spends on purchase of fossil fuel 1.56 times more than its income from the export of Nepalese commodities and the gap is widening very rapidly (Source:Nepal in Figures, 2012)

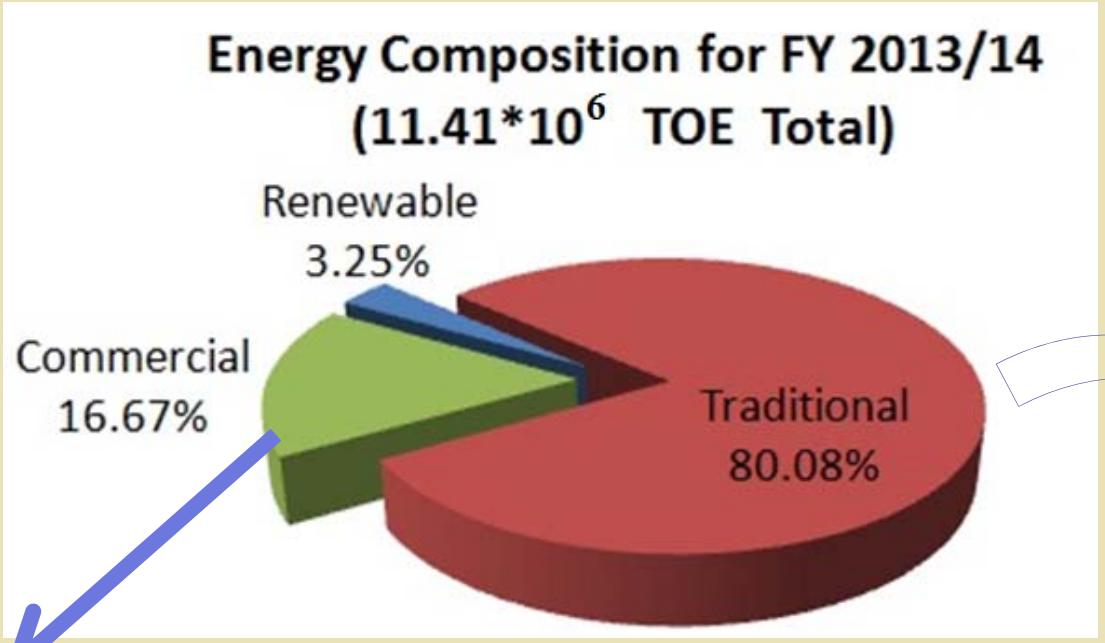
Energy Trends in Nepal

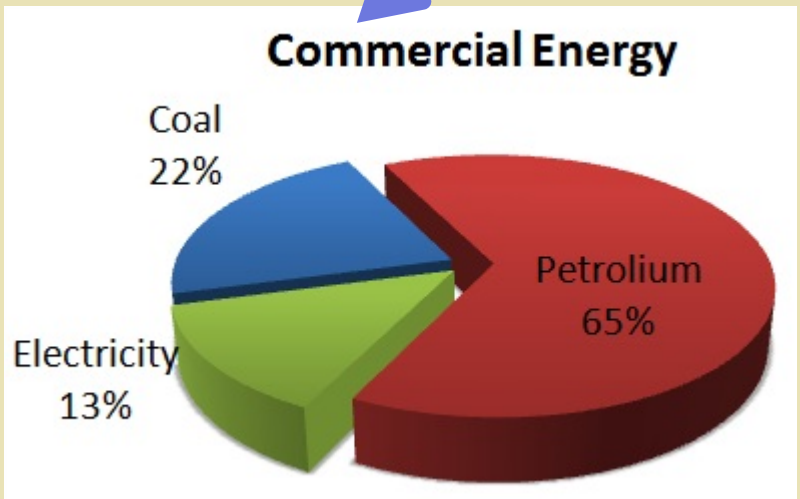


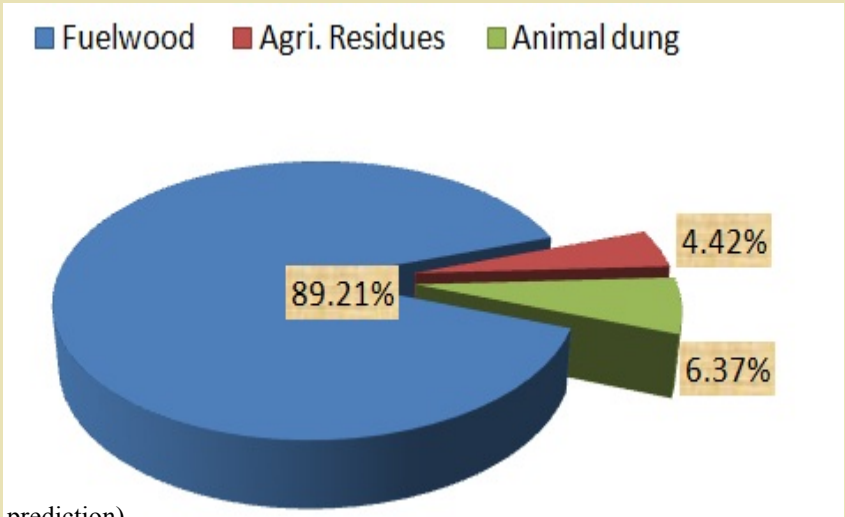
	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14*
Renewable	64	70	75	109	166	371
Commercial	1138	1464	1580	1679	1854	1903
Traditional	8085	8342	8500	7032	8017	9140

* Whole year estimation from first 8 months real data

Energy Trends in Nepal (Per Capita Energy Consumption: 17 GJ)







Source: Economic Survey, Ministrt of Finince, July 2014 (based on 8 months prediction)

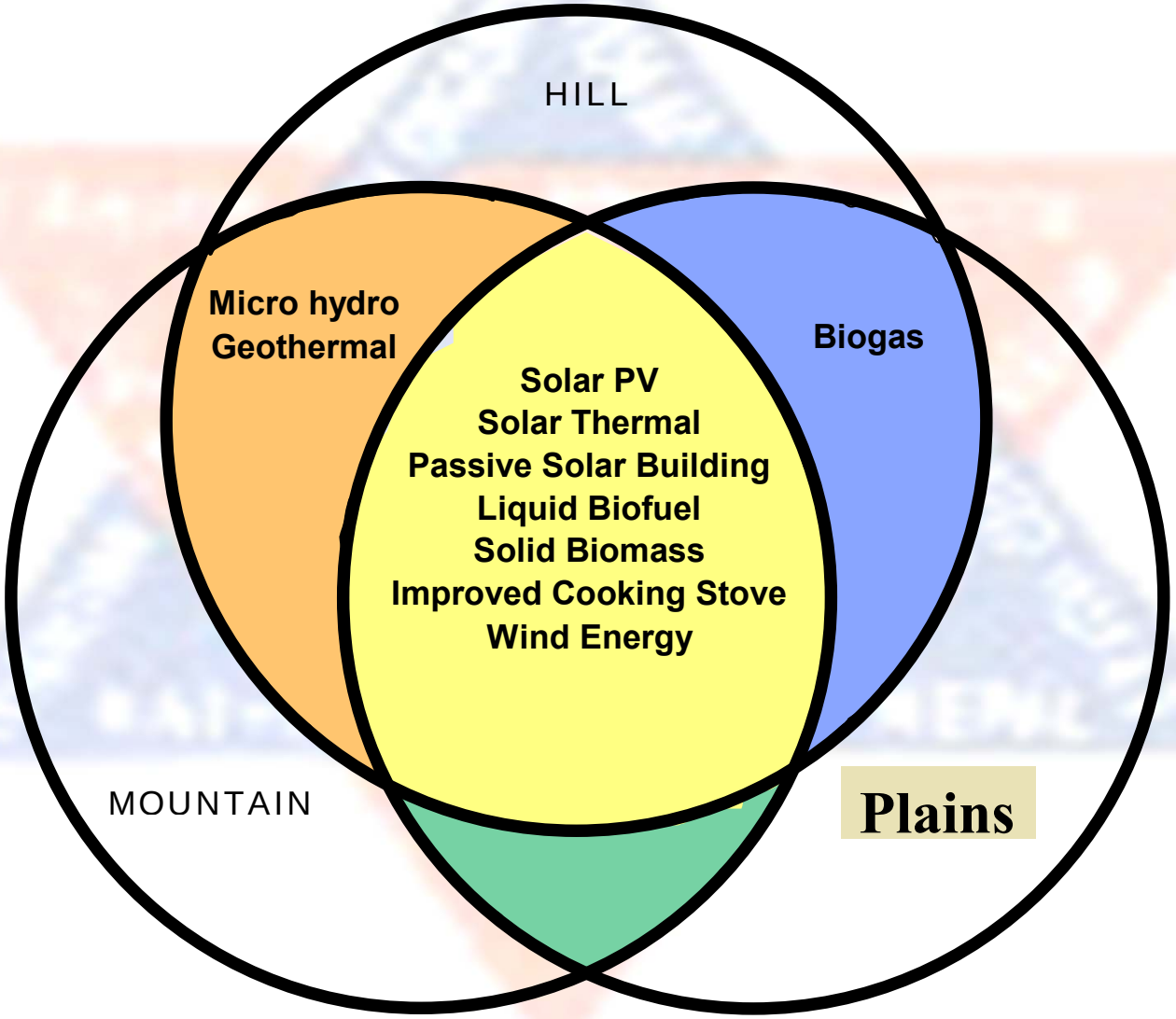
Hydro Power Capacity Balance: Wet and Dry (Source: SSB, NEA, May 2014)

SOURCE	DETAILS	MW
ROR	Installed Dependable	620 590
STORAGE	KL 1 +KL2	92
THERMAL	Installed Dependable	54 25
IMPORT	Total Treaties PEX Trading	75 25 50 0
Total Available	Dependable	782
DEMAND	Off Peak Peak	600 1150
Deficit	Off Peak	0
	Peak	368

SOURCE	DETAILS	MW
ROR		202
STORAGE	KL 1 +KL2	92
THERMAL	Installed Dependable	54 25
IMPORT	Total Treaties PEX Commercial Trading	195 25 50 90 30
Total Available	Dependable	514
DEMAND	Off Peak Peak	600 1201
Deficit	Off Peak	203
	Peak	686
Load shedding	Hrs/day	12~14

Electricity Consumption per Capita:95 kWh (after loss)

Suitability of Renewable Energy Technology by region



Barrier: No Government support for Solar PV in areas with NEA utility even if load shedding exceeds for more than 16 hours/day

Stages of Development of RETs

Technology/ Potential	Stage of Development									
	Fundamental R & D	Resource Data	Adoptive R & D	Demonstration	Dissemination	End-use Diversification	Commercialization	Needs Financing Assistance	Needs HRD	Needs to develop quality control and monitoring n mechanism
Microhydro/>100 MW		✓			✓	✓	✓	✓	✓	✓
Solar PV		✓	✓	✓	✓		✓	✓	✓	✓
Solar Thermal		✓	✓	✓	✓				✓	✓
Passive Solar Building		✓	✓	✓						
Biogas/1.1 Million	✓		✓		✓	✓	✓	✓	✓	✓
Liquid Biofuel		✓	✓	✓						
Solid Biomass		✓	✓	✓			✓			
Improved cooking stove/2.5Million	✓		✓	✓	✓			✓	✓	
Wind Energy/3000 MW		✓	✓	✓						
Geothermal	✓	✓	✓	✓						

✓Represents present stage of activity and needs improvement

Established CE Organisations

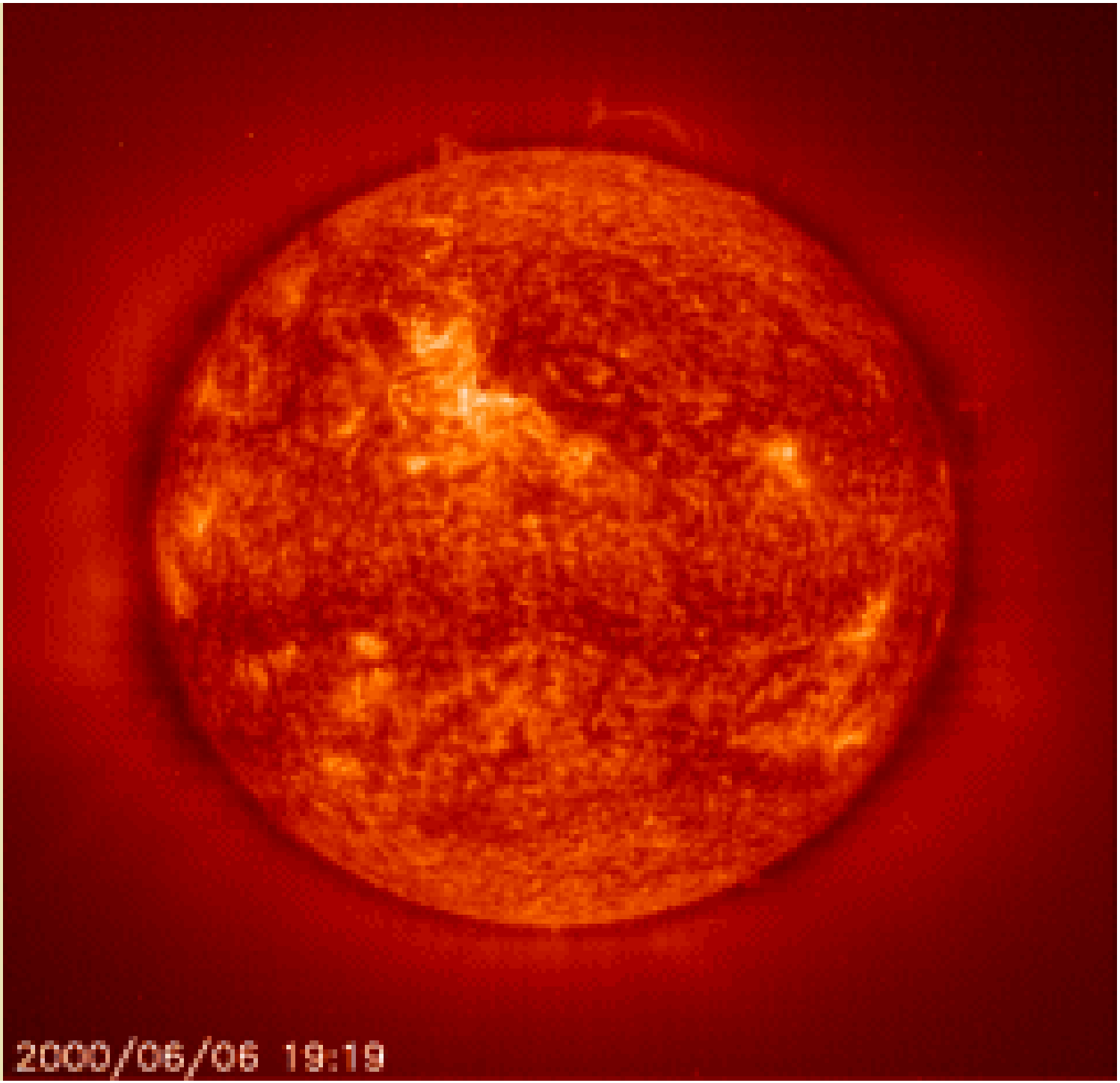
- NMHDA with more than 25 companies
- SEMAN with 100 solar companies
- NBPA with more than 50 biogas companies

A Way Forward

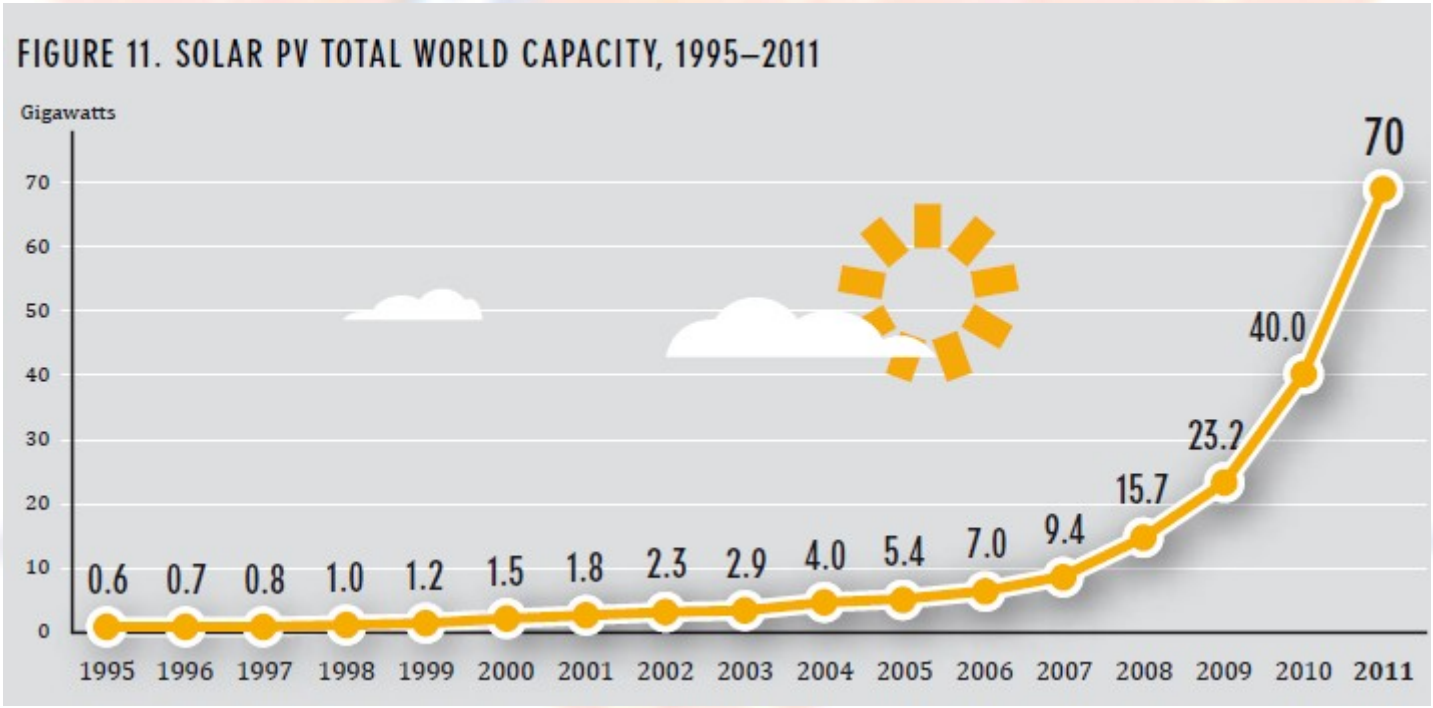
The SUN

Source of all Energy

Produces Energy from H_2



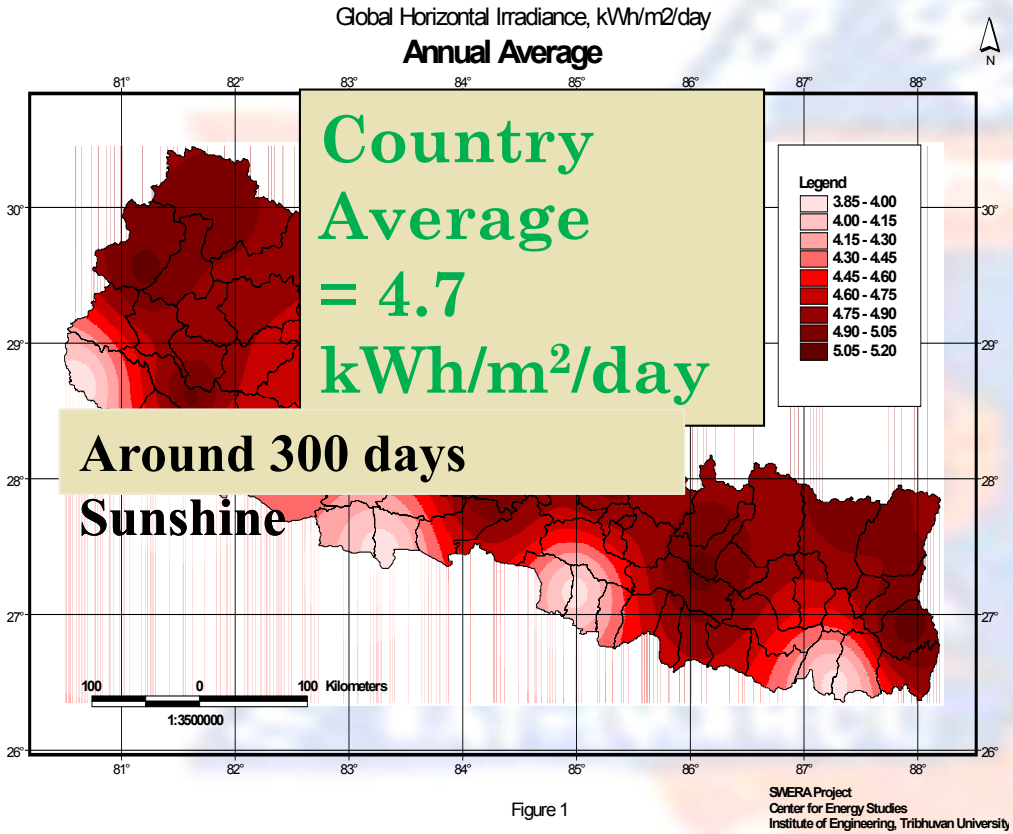
PV Development



137 GWp installed by Dec 31, 2013

More than 80% is grid connected

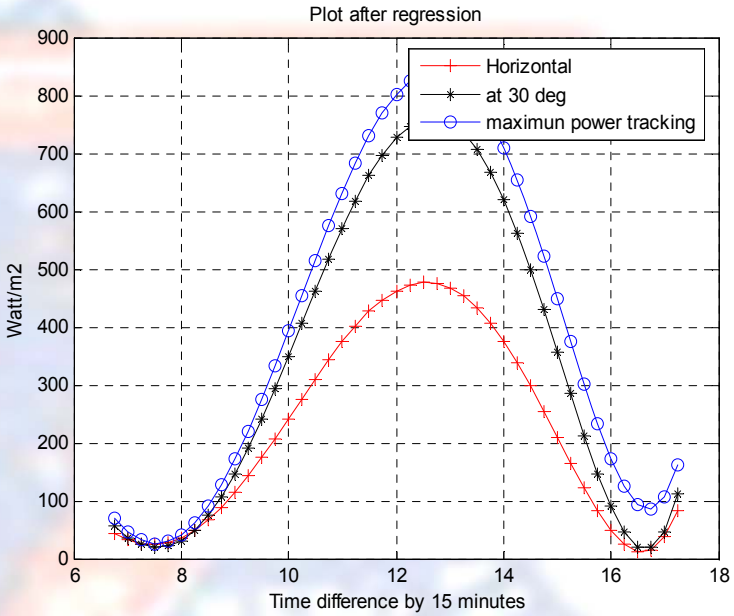
Solar Energy Potential in Nepal



Country Average = 4.7 kWh/m²/day

Around 300 days Sunshine

Figure 1



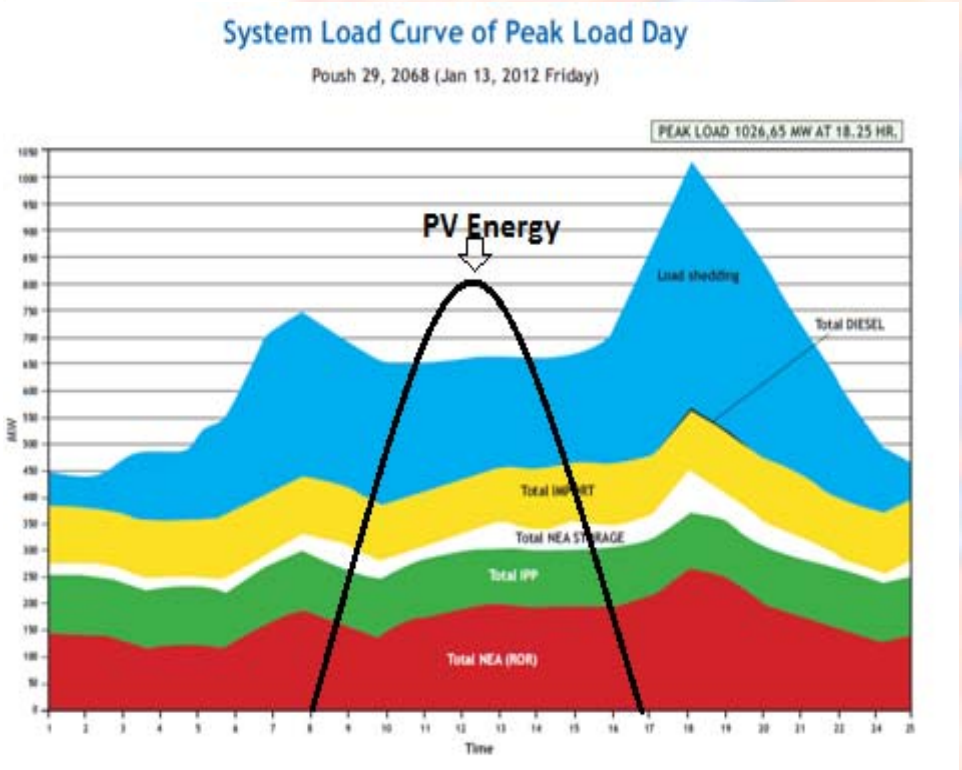
Date: 2068/08/03, cloudy day
Location: CES Building
(Latitude:27°41'0"N(27.683°N)
Longitude:85°19'14"E(85.321°E)
Sun Rise: 6:45am, Sun Set: 5:07pm

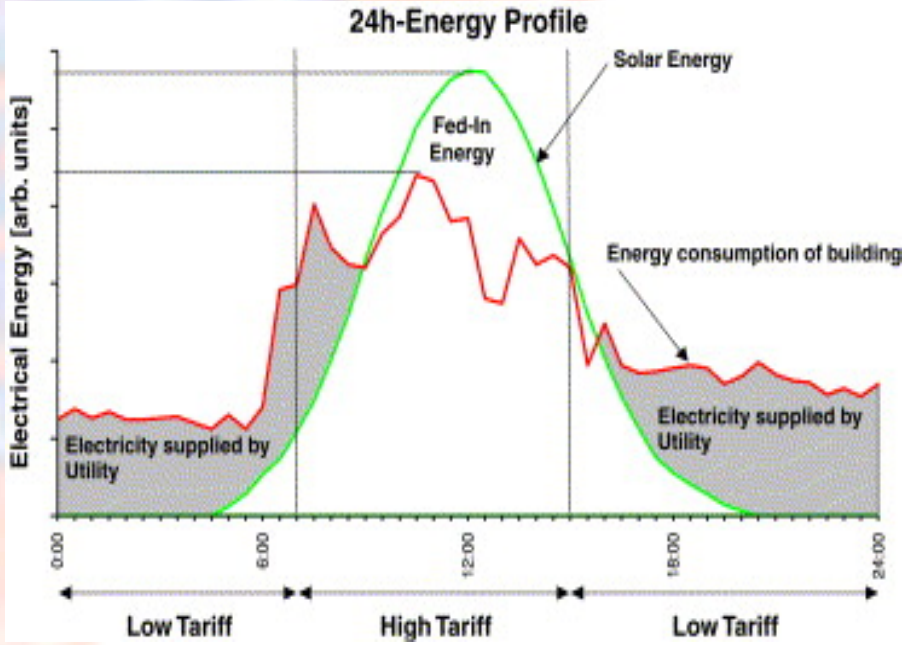
Solar Energy is one of the best alternatives for Nepal.

- NEA has 92MW of reservoir type hydropower plant(Kulekhani I & II)

How load shedding can be compensated?

- PV produce energy in phase with higher demand profile.





Day time saving is one of the best ideas for load shedding reduction

Peak System Load 1200.98 MW in Nov 3, 2013 at 18.25 Hours

Application of PV based Power in Nepal

More than 4,000 solar technicians of Level 1 and Level 2 have been rained and certified by CTEVT

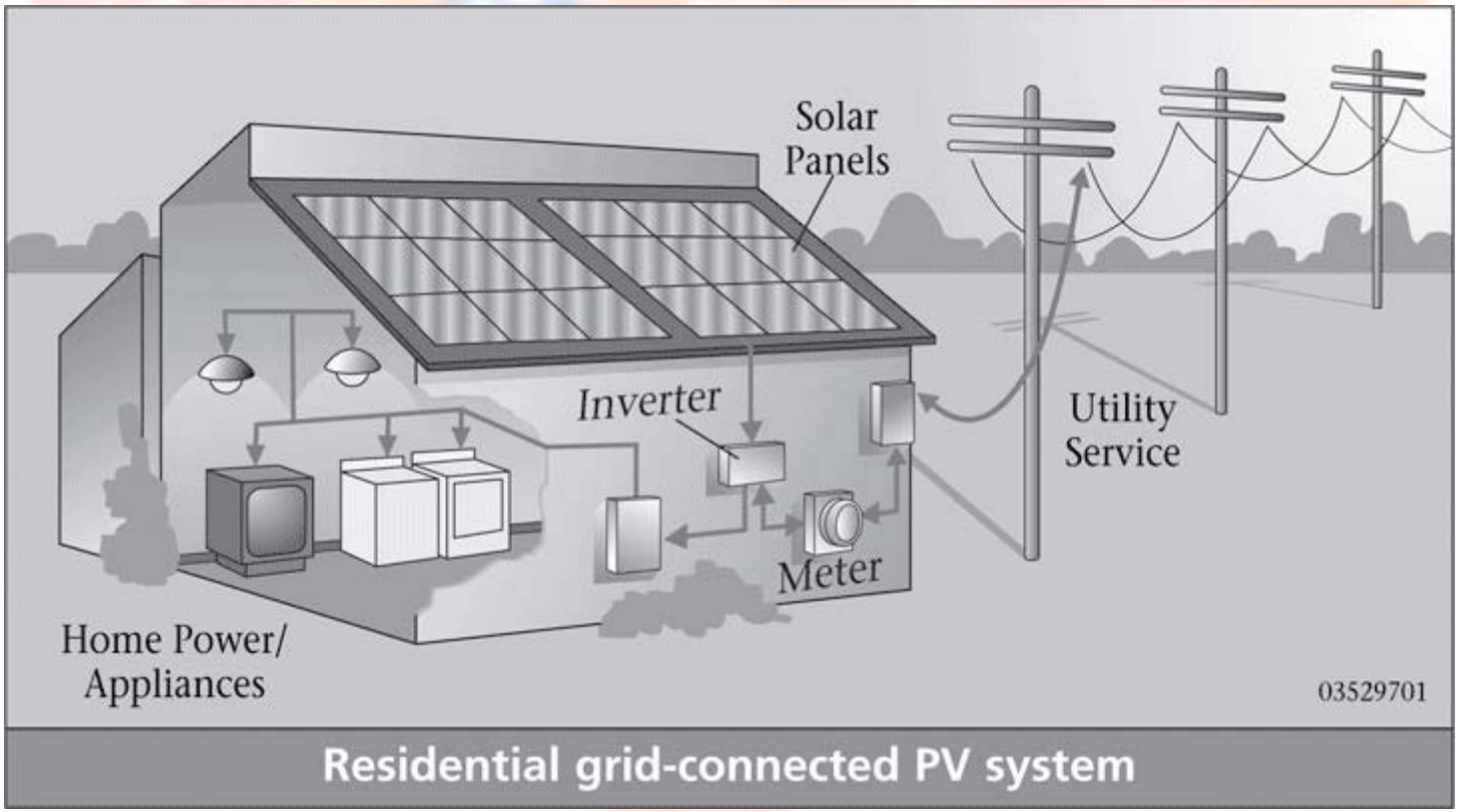
This total does not include PV power being used in Army and Police)
(Source: Based on Interaction programme held at NAST on 8 July 2013, Courtesy Prof. Dr. Jagan Nath Shrestha)
(

S/N	Service/Institution	Installed PV Power, kWp	%
1	Nepal Telecom	9000	28.125
2	NEA	100	0.003
3	SHS/AEPC	12000 (400,000 Systems)	37.500
4	Institutional Solar PV System/EU/AEPC	9900	30.937
5	Water Pumping/KUKL	780	0.024
6	Civil Aviation	50	0.001
7	Misc	170	0.005
	Total	32000	

PVGC System ?

Residential Grid-connected PV system

Klaus Töpfer, ex-Federal Minister for the Environment and current executive director of the Institute for Advanced Sustainability Studies (IASS), commented, "When photovoltaics first took off in Germany and the 1000-roof program was launched in the fall of 1990, nobody expected that we would already reach the one-million-system mark by 2011." (17.2 GW)



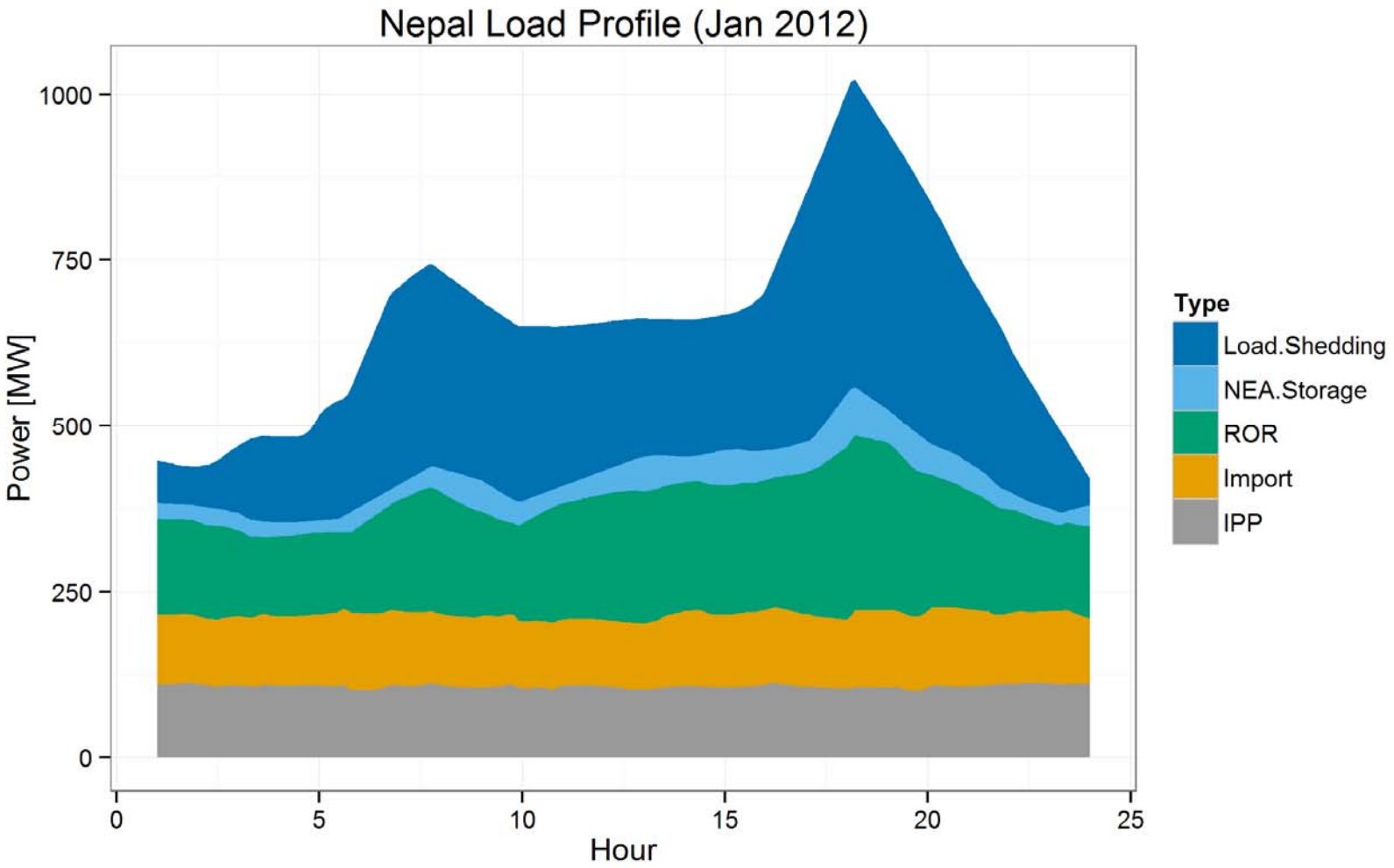
As of Dec 2013cumulative installed PV Power exceeds 137 GW and about 85% is connected to grid

P1 Location: Pulchowk Campus, TU, CES/IOE

with load shedding, **without** backup system

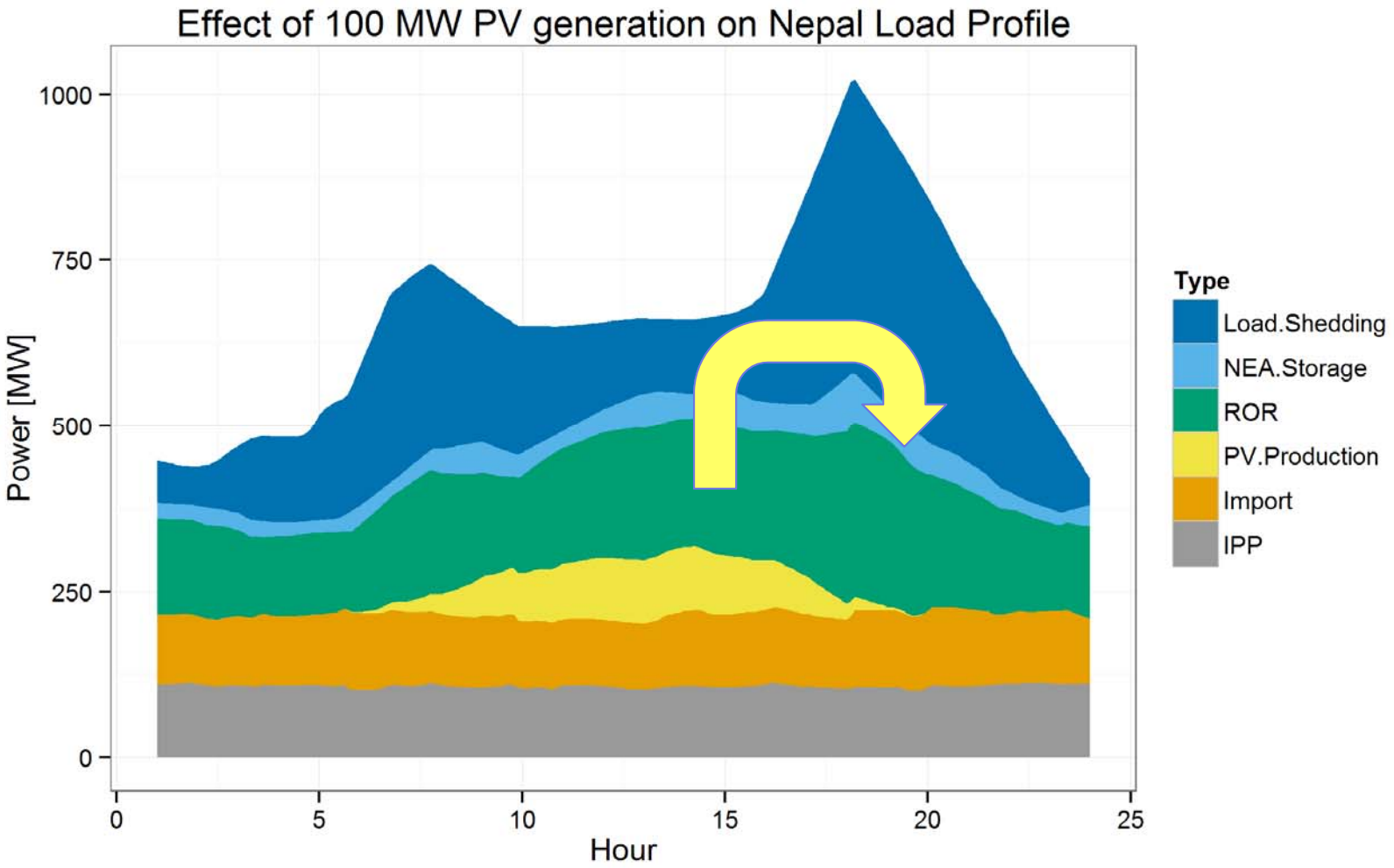
Energy Injected 2.2 kWh/kWp/day

Load profile and load shedding - Jan 2012



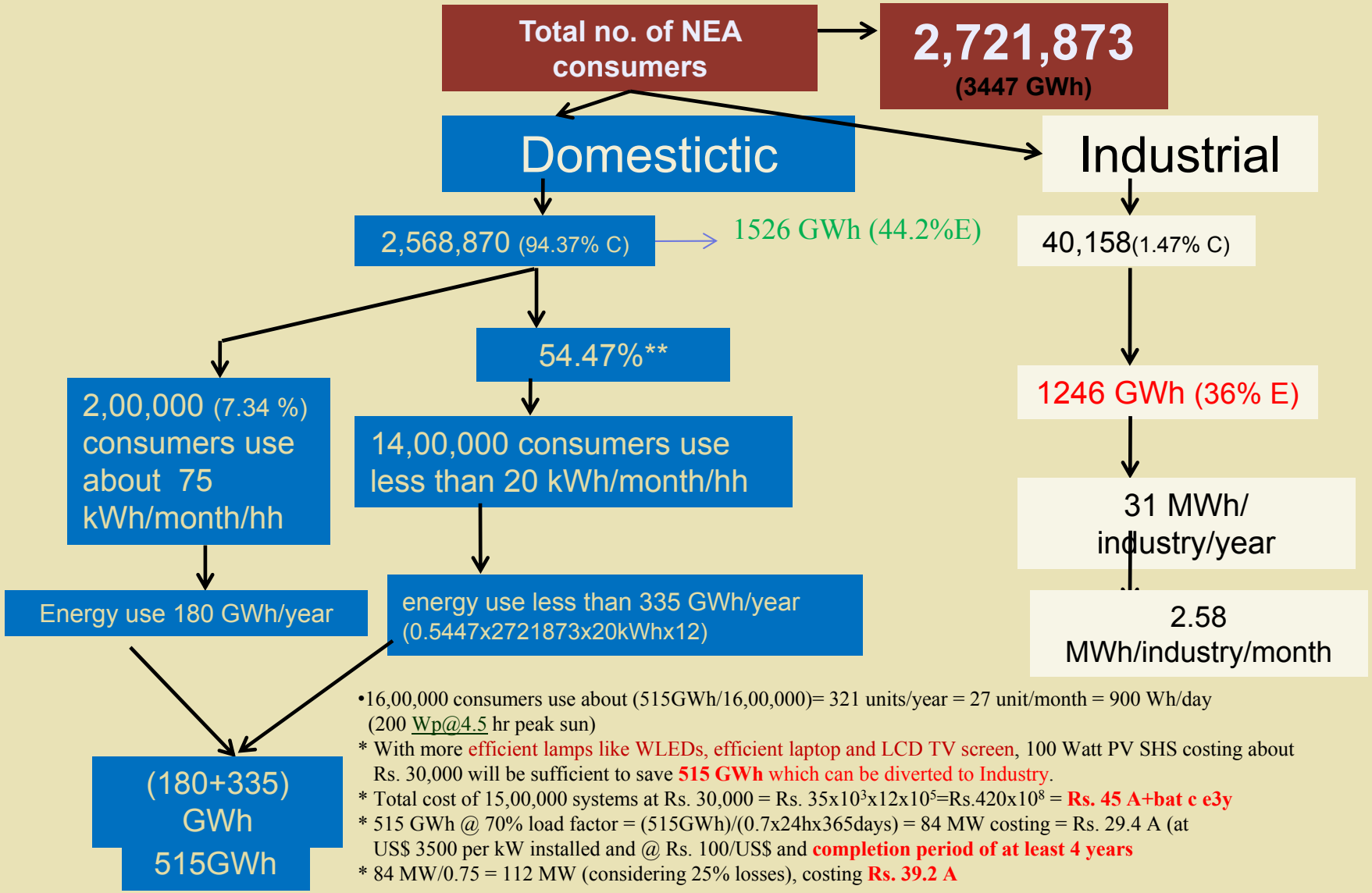
Load profile and load shedding - Jan 2012

Example of the effect of 100MW PV plant grid-connected



Nepal Electricity Authority, A Year in Review- Fiscal Year 2013/14, 17 August 2014 (1 Bhadra 2071)

Total Electricity Sales 3444 GWh (Estimated for 2013/14)



•16,00,000 consumers use about (515GWh/16,00,000)= 321 units/year = 27 unit/month = 900 Wh/day (200 Wp@4.5 hr peak sun)

* With more efficient lamps like WLEDs, efficient laptop and LCD TV screen, 100 Watt PV SHS costing about Rs. 30,000 will be sufficient to save **515 GWh** which can be diverted to Industry.
* Total cost of 15,00,000 systems at Rs. 30,000 = Rs. $35 \times 10^3 \times 12 \times 10^5 = Rs.420 \times 10^8$ = **Rs. 45 A+bat c e3y**
* 515 GWh @ 70% load factor = (515GWh)/(0.7x24hx365days) = 84 MW costing = Rs. 29.4 A (at US$ 3500 per kW installed and @ Rs. 100/US$ and **completion period of at least 4 years**
* 84 MW/0.75 = 112 MW (considering 25% losses), costing **Rs. 39.2 A**

Immediate PV Power Demand in Nepal (330 MWp)

- Demand for PV GC System: 100 MWp
- Demand for domestic System: 150 MWp
- Government Sector demand (10 am to 5 pm): 80 MWp

Solar Electricity in Gulf Countries

Saudi Arabia

- Saudi Arabia has announced a plan to install 41 GW (16 GWp PV+25 GW CSP) worth of solar by 2032
- The World's largest crude oil producer Saudi ARAMCO has installed 1.78 MWp PV in Riyadh in May 2014 with the help of Canadian Solar

Qatar

- Qatar seeks to generate 16% of its electricity from solar power by 2018 and is expected to complete the installation of 1800 MW solar power plant in 2014
- Solar Panel factory in Qatar produces 300 MW of PV power/year and plans to produce 2.5 GW/year

Because Solar Electric is……..

- Cheaper than Diesel/Petrol Plant
- 100% Clean Energy
- Easy to Transport
- Option to choose a size of your need & budget
- Quick Installation
- Accessible in rural and urban
- Possible for off-grid and on-grid
- Highly feasible as the average temperature is below 30^0C but 330 sunny days a year
- Can be installed very quickly
- Solar Electric is one of the best possible options for rural & urban electrification but challenging

Challenges

- Reduce cost of CE technology
- Reduce subsidy and increase credit
- Ambiguity policy
- Remote areas
- Less affordability of people
- Lack of Coordination
- Difficulty in retaining technical personnel

Empowering Solar Companies

- Ensure capable technical manpower (MWp Range)
- Increase fund for investment
- Introduce updated technology
- Digitise activities of companies
- Improve after sales services activities
- Follow approved code of conducts
- Adopt policy to link with financing and academic institutions
- Adopt free market policy

Suggestions

Adopt Energy Mix Policy

Reform Policy for more wider use of RETs/solar electricity in Urban Areas by providing (soft loans, tax rebates, FIT approach, green certificates to users,..)

Make mandatory Policy to include at least one type of RET while constructing new houses in urban areas (at least 5% of total energy from RE sources?)

Blend Technology with Social Science for measurable social benefits and involve University resources for development

UN Goal: Universal Energy Access by 2030

UN's Sustainable Energy for All (SE4ALL) Objectives:

- universal access to modern energy sources

- double the share of RE in the global energy mix

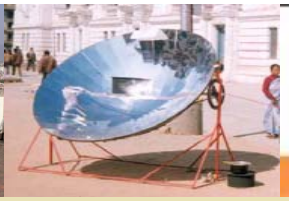
- double the rate of improvement of energy efficiency


Happy users of Solar Electricity

Thank you!

THANK YOU FOR YOUR KIND ATTENTION






National Rural and Renewable Energy Program

Subsidy and Delivery Mechanism -Proposed for Roof Top Program-

- For rooftop solar system from 500 Wp - 2 kWp, subsidy proposed @ NRP 5,000 per 100Wp
- In addition provision for providing soft loan through bank at the interest rate of 4% by using PV system as collateral
- In addition provision proposed for income tax exemption (amount equal to 25% of system cost) and 50% exemption of tax on land and house rental.)

- **(Source: As per Mr. Samir Thapa, AEPC, Presentation at stake holder's meeting on 16 Oct 2014, in presence of Hon. Member of CAII Mr. Gagan Thapa)**

Main Goal

Create new environment in Nepal **free of poverty and injustice** in which **guaranteed sustainable renewable energy sources** are used to improve the **quality of life** of people.

HYDRO SOURCES (Source: SSB, NEA, May 2014)

S. No.	NEA Plants	Installed	Lowest available
1	Kaligandaki	144	44
2	Marsyangdi	69	21
3	M.Marsyangdi	70	22
----------	----------		
Total NEA ROR		380	122
	IPP Plants		
1	Khimti	60	18
2	Bhotekoshi	36	12
-------	----------	----------	----------
Total IPP ROR		240	80
All Total ROR		620	202

WHY RENEWABLE ENERGY FOR NEPAL?

RURAL CONTEXT

- Difficult terrain and Remoteness
- Scattered and Sparse population
- Low load

the extension of grid-based electricity is more expensive than the alternative

URBAN CONTEX

समूह/वार	आईतवार	सोमवार	मंगलवार	बुधवार	बिहीवार	शुक्रवार	शनीवार
समूह-१	०६:००-०७:३० १४:००-१५:००	०८:३०-११:०० १९:००-२१:००	११:००-१३:०० ०७:००-२२:००	१०:००-१२:०० १९:३०-२१:३०	१३:००-१४:०० १९:००-१९:३०	०७:३०-१०:०० १८:००-२०:००	०६:३०-०८:३० १५:००-१८:००
समूह-२	०६:३०-०८:३० १५:००-१८:००	०६:००-०७:३० १४:००-१५:००	०८:३०-११:०० १९:००-२१:००	११:००-१३:०० ०२:००-२२:००	१०:००-१२:०० १९:३०-२१:३०	११:००-१४:०० १९:००-१९:३०	०७:३०-१०:०० १८:००-२०:००
समूह-३	०७:३०-१०:०० १८:००-२०:००	०६:४०-०८:४० १६:००-१८:००	०६:००-०७:४० १४:००-१६:००	०८:४०-११:०० १९:००-२१:००	११:००-१४:०० २०:००-२२:००	१०:००-१२:०० १९:३०-२१:३०	१४:००-१७:०० २१:००-२२:३०
समूह-४	१२:००-१४:०० २१:००-२३:३०	०७:३०-१०:०० १८:००-२०:००	०६:२०-०८:३० ११:००-१६:००	०६:००-०७:३० १४:००-१६:००	०८:३०-११:०० १९:००-२१:००	११:००-१३:०० २०:००-२२:००	१०:००-१२:०० १९:३०-२१:३०
समूह-५	१०:००-१२:०० १९:३०-२१:३०	१४:००-१७:०० २१:००-२३:३०	०७:३०-१०:०० १८:००-२०:००	०६:२०-०८:३० १६:००-१८:००	०६:००-०७:३० १४:००-१६:००	०८:३०-११:०० १९:००-२१:००	११:००-१३:०० २०:००-२२:००
समूह-६	११:००-१३:०० २०:००-२१:००	१०:००-१२:०० १९:३०-२१:३०	१३:००-१४:०० २१:००-२३:३०	०७:३०-१०:०० १८:००-२०:००	०६:३०-०८:३० १६:००-१८:००	०६:००-०७:३० १४:००-१६:००	०८:३०-११:०० १९:००-२१:००
समूह-७	०८:३०-११:०० १९:००-२१:००	११:००-१३:०० ००:००-२१:००	१०:००-१२:०० १९:३०-२१:३०	१३:००-१४:०० २१:००-२३:३०	०७:३०-१०:०० १८:००-२०:००	०६:३०-०८:३० १६:००-१८:००	०६:००-०७:३० १४:००-१६:००

RETs are considered as

- Mainstream energy supply in rural areas
- Alternative of existing supply system in urban areas

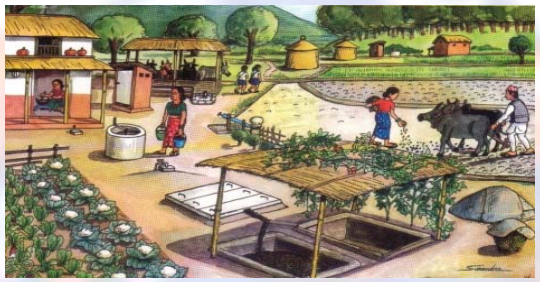
Moreover RETS enables

1. Decentralized Energy Solution
2. Regional and Local Development
3. Local Employment Generation

VARIOUS RETS PROMOTED IN NEPAL

(Source:RPD, AEPC, July 2014)

Micro-hydro



HHs Biogas

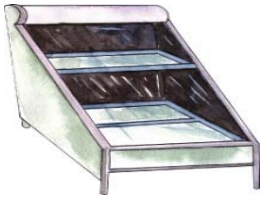
Wind

IWM

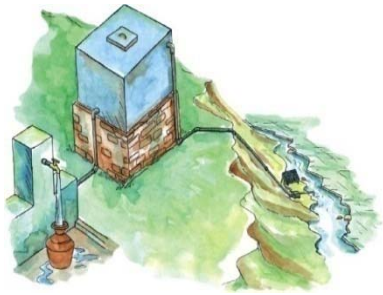
ICS

Bio-fuel

SHS



Solar dryer & cooker



Institutional Solar System/Solar water pumping

PROSPECTS: FAVORABLE GEO PHYSICAL SITUATION (Source:RPD, AEPC, July 2014)

S.N.	Technologies	Estimated Potential	Basis
1	Mini/micro Hydro	>100 MW	Possible in 55 districts of Nepal
2	Domestic Biogas	1.1 million plants	At existing livestock population
3	Solar Energy	2,100 MW	4.5 kWh/m^2/day radiation if 2% area is taken as suitable
4	Improved Cooking Stove	>2.5 Million	Considering 75% eligible households as of total household of 2001 census
5	Improved Water Mill	25,000 -30,000	
6	Wind	3,000 MW	Considering 10% of area with more than 300 W/m^2
7	Bio-fuel	11,00,000 tons	

Source: AEPC, 2010

PROSPECTS: FAVORABLE POLICY ENVIRONMENT

- Energy promotion has been an integral part of the national development agenda since 1985
  - Hydro Policy, Rural Energy Policy and Climate Change Policy
  - Dedicated institution for RE promotion
- Strong private sector (57 MHP,37 Solar,70 Biogas PQ companies)
- Strong commitment from development partners: USD 200 million commitment already for next 5 yrs
- High dependence on imported petroleum products
  - 100 billion NRs (5% of total budget; 1900 billion) was

Country Overview

- ✓ Country: Nepal, Capital: Kathmandu
- ✓ Area: 147,181 Sq KM, Population: 28 million
- ✓ Political System: Constitutional Republic
- ✓ Neighboring Countries: India and China
- ✓ Latitude: 28 º North , Longitude: 84 º East
- ✓ Temp. in Capital: Min. -1^{0}C in Feb. & Max. 35^{0}C in June
- ✓ Highest peak of the world Mount Everest lies in Nepal
- ✓ Altitude/height of Mt. Everest : 8,848 meters
- ✓ Nepal has 6.8 sunshine hours per day on an average
- ✓ It is estimated that 2,100 MW power can be generated from solar energy if 2 % area of Nepal is considered

Current Scenario

- Diverse community
- Scattered houses
- More than 100 ethnic groups with own unique/ rich culture living in the same society
- 2-15 hours/day load shedding throughout the year
- Expensive to construct hydro project, its transmission line & peripherals
- Unaffordable hydro-project at individual level
- Low income
- Still preference is own & individual property

Consequence is……

Source; WARES, 2012

UN Goal: Universal Energy Access by 2030

UN's Sustainable Energy for All (SE4ALL) Objectives:

- **universal access to modern energy sources**
- **double the share of RE in the global energy mix**
- **double the rate of improvement of energy efficiency**

24 V C, 300 Watt, 3 Liter, Rice Cooker

(Energy required to cook 1kg of rice is about 300 Watt * 0.5 hour = 150 Wh, 6.25 Ah at 24 V DC, 30 Wp Module with 5 h peak sun)

(costing Rs. 4/cooking (assuming PV module lasts for 20 years, using two 18 Ah 12 V DC deep cycle battery 4 nos. costing Rs 200/Ah) and 4 nos of rice cookers costing at $30/pc)

(1 US$ = NRs. 98)

How Can World Community help in reducing GHGs

- World Population: 7.2 Billion
- 50% of World Population are using biomass for cooking mostly in Solar belt countries(720 Million hhs @5 p/hh)
- Total CO2e emitted 5.3 Million Tonnes/DAY (@ 720 Million hhs* 3kg biomass/hh* 2.47 kg of CO2e/kg of biomass)
- Benefits through Carbon Trading/CDM $ 106 Million/DAY (@ $20/ton of CO2e avoidance)
- Cost of Solar Electricity based cooking $ 98 Million/DAY (@ $1000/equipment cost /hh, consisting PV module, 24 V DC Battery, 300 Watt, Rice Cookers including replacement costs, lasting for 20 years)
- Benefits from time saved in collecting biomass and reduction in medical expenditures due to clean environment in kitchen are not calculated

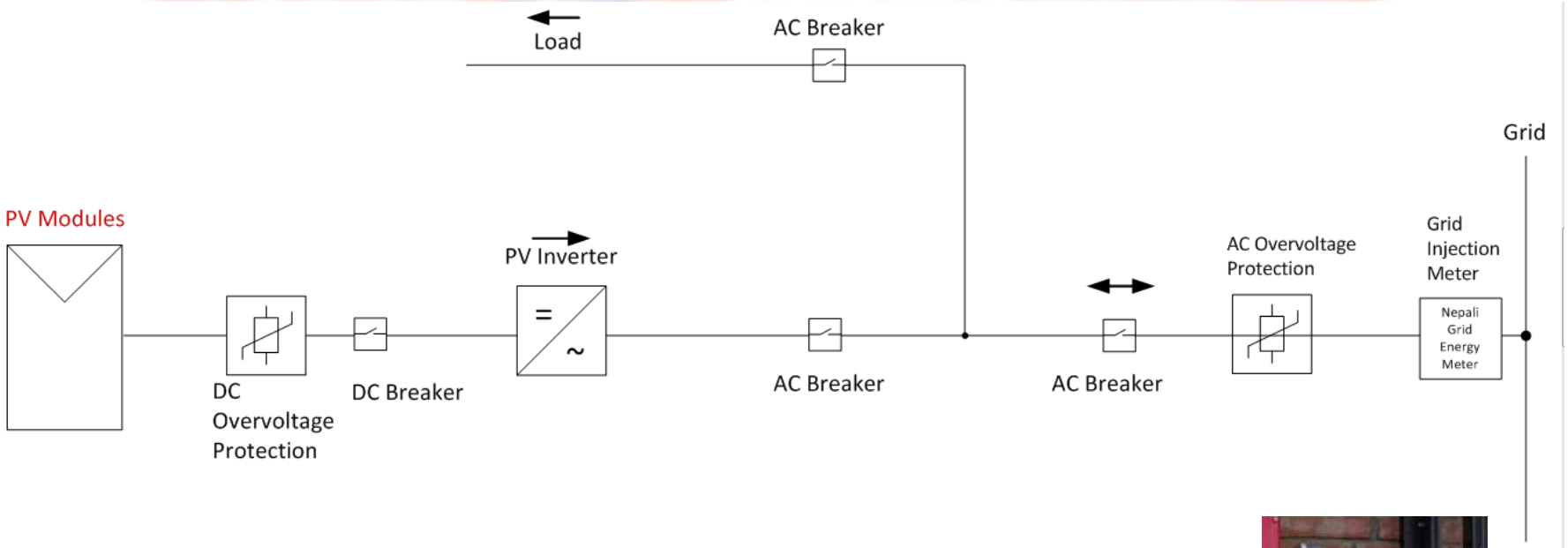
Impact of Load Shedding

- There is no load shedding for well to do people (<5%)
- There is always load shedding for people in rural areas (>50%)
- Impact of load shedding is heavily felt among middle class people specially in urban areas
- Impact of load shedding is heavily felt in industries

Cost of 1 kWp BIPVES (as of 1 Jan 2014)

- 1 kWp PV Array(25 years warranty) Rs. 1.00 Lakhs
- Grid Connector Rs. 1.00 Lakh
- Support Structure Rs. 0.25 Lakh
- Installation Cost Rs. 0.25 Lakh* **(GoN Subsidy Rs. 50K)**
- 200 Ah Battery backup Rs. 0.25 Lakh
- Total Cost around Rs. 275,000.00
- **Certificate of Green Energy Producer**
- **(NRs. (275,000/((25*12)*(1kW*5h/day*30 days))= Rs 6/unit (for the first 3 three years which is less than the present cost of NEA tariff**
  (and Rs. 11/unit for another 22 years *(if battery is replaced 8 times and battery cost remains constant))*
- May vary from place to place
- **100,000 houses will produce 100 MWp and (5 kWh/day/hh*100,000hh) 500 MWh per day in Kathmandu valley alone**

Schematic P1
Location: Pulchowk Campus, Tribhuwan University, CES/IOE
with load shedding, **without** backup system

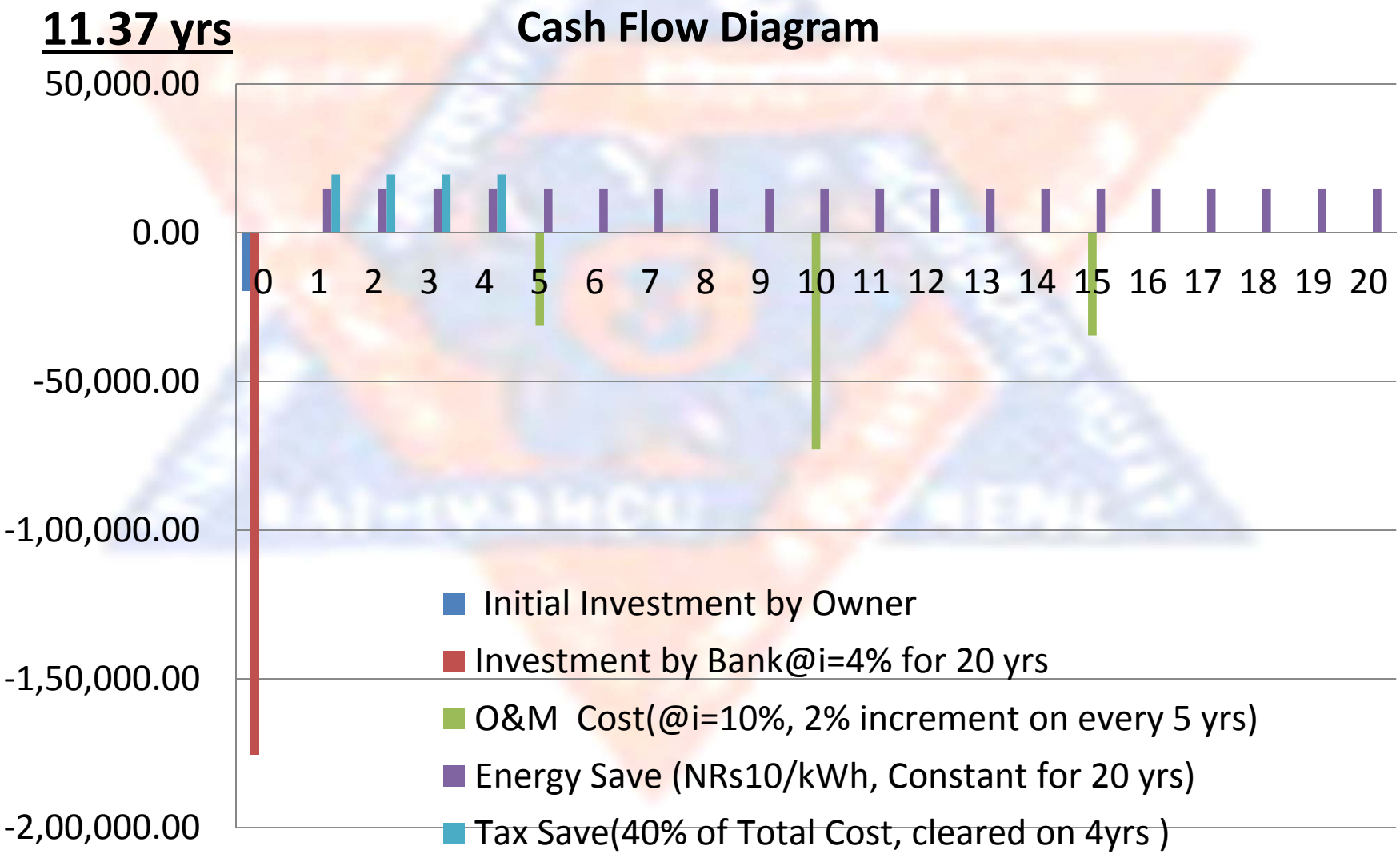


Project Summary

PVGC system(kWatt)	1.00	
Total Initial investment (NRs)	195,000.00	
Loan amount (NRs)	175,500.00	90% of Total Cost at 4% interest rate paid in 20 yrs of project life.
Owners Investment (NRs)	19,500.00	Assumed to take loan at 10% interest rate
Tax incentives to owners(NRs)	78,000.00	40% of Total Cost, Rebate in 4 years
Peaksun(Hrs)	4.50	
NEA tariff(NRs/kWh)	10.00	Initial tariff
kWh/year from PV at Inverter O/P	1,478.25	4.05kWh/kWp/day at Kathmandu
Cost of Inverter after 10 yrs (NRs)	40,000.00	Needs to be replaced in 10th year
Cost of Batteries(NRs) (200Ah Solar Tubular Battery)	29,832.00	Cost increment by 5 %in every 5 years replacement.
Project Life(Years)	20.00	
Net Present Value (NPV) of cost(NRs)	250, 18.00	Including the cost of operation and maintenance
Cost of energy in DG sets(NRs)	33.00	Increment by 12%/year

Cash flow diagram for 3 different option and Payback Period

Option A: NEA tariff is NRs10/kWh and remains constant throughout the 20 years : Compounded Payback Period: 11.37 yrs



Cash flow diagram for 4 different Options and Payback Period

(Comparison of 1 kWp PVGC with different NEA Tariffs and Diesel based Electricity)

- **Option A: NEA tariff is NRs10/kWh and remains constant throughout 20 years : Compounded Payback Period: 11.37 yrs**
- **Option B: NEA tariff is NRs10/kWh and increases by 7% per year: Compounded Payback Period: 7.88 yrs**
- **Option C: NEA tariff is NRs10/kWh and increases by 20% in every three years: Compounded Payback Period: 8.59 yrs**
- **Option D: When compared with NRs 33/kWh of Diesel Energy and increases by 12%/year, the payback of PVGC system is found to be 3.0 yrs.**