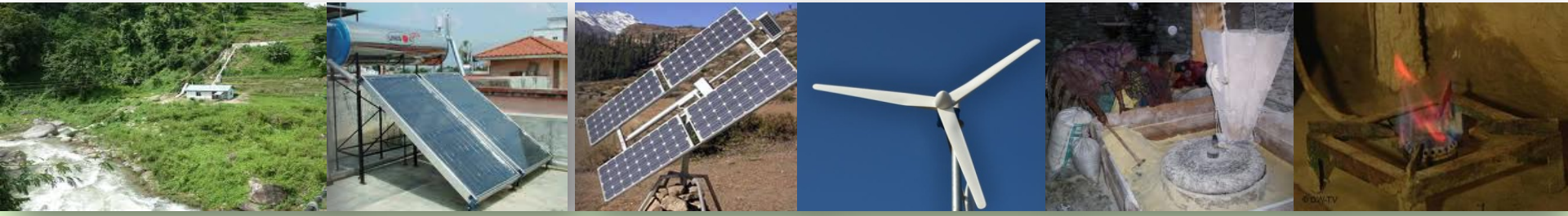
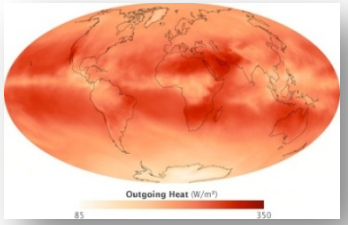
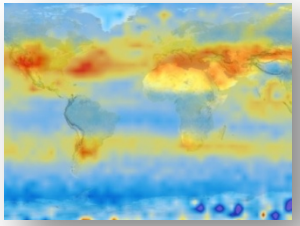
International Workshop on
Asia- Pacific Regional Initiative on Energy, Environment and Ecosystem (3E) Nexus for Sustainable Development
24-25 Feb 2014, Maldives



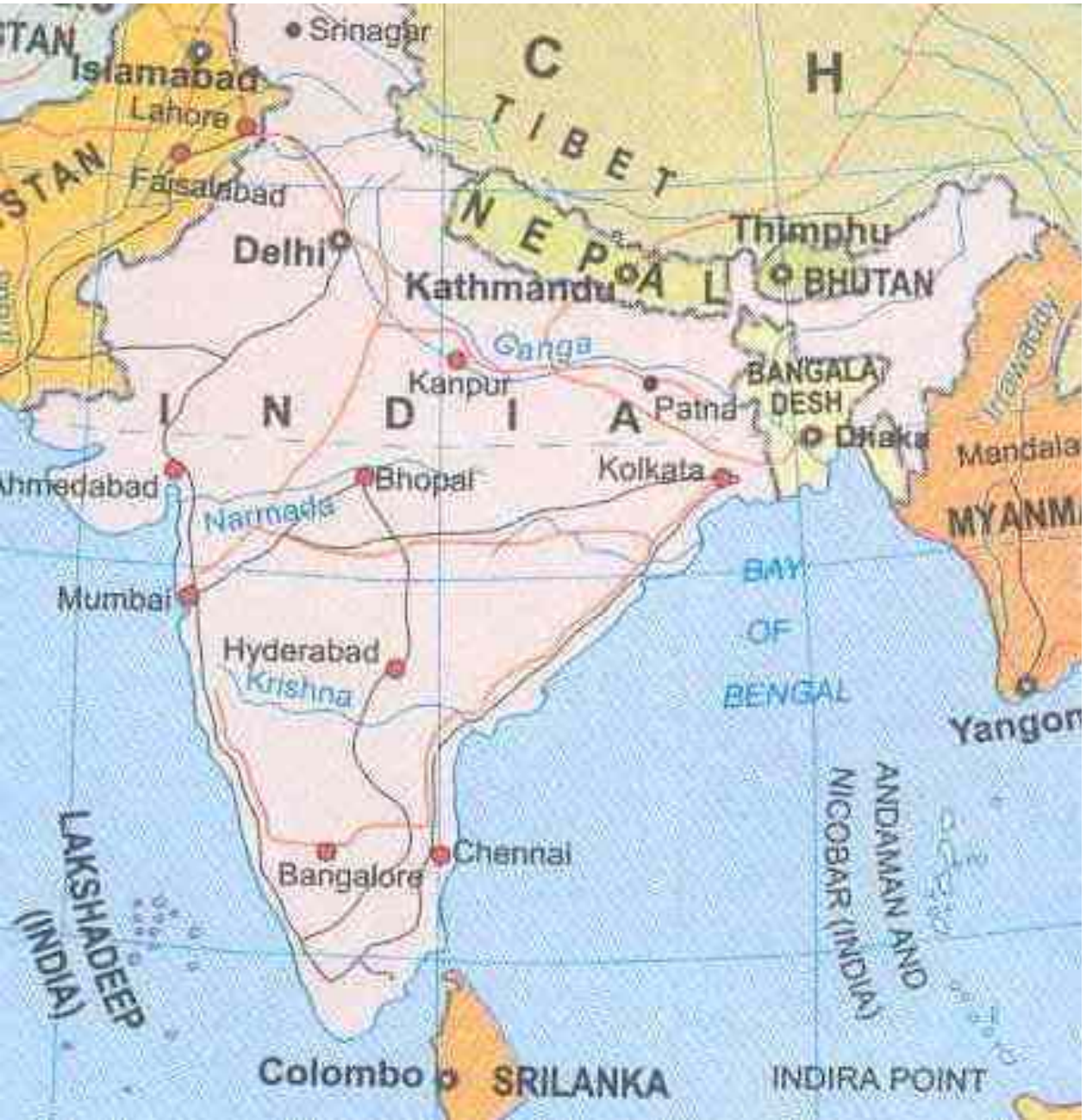
Renewable Energy Technology and Climate Change Mitigation in Nepal





Prof. Tri Ratna Bajracharya, Ph.D.
Director, Centre for Energy Studies
Institute of Engineering, Tribhuvan University. Nepal

NEPAL: Location, Area, and Population



Land Area-147181 Sq km

Population~28 Million

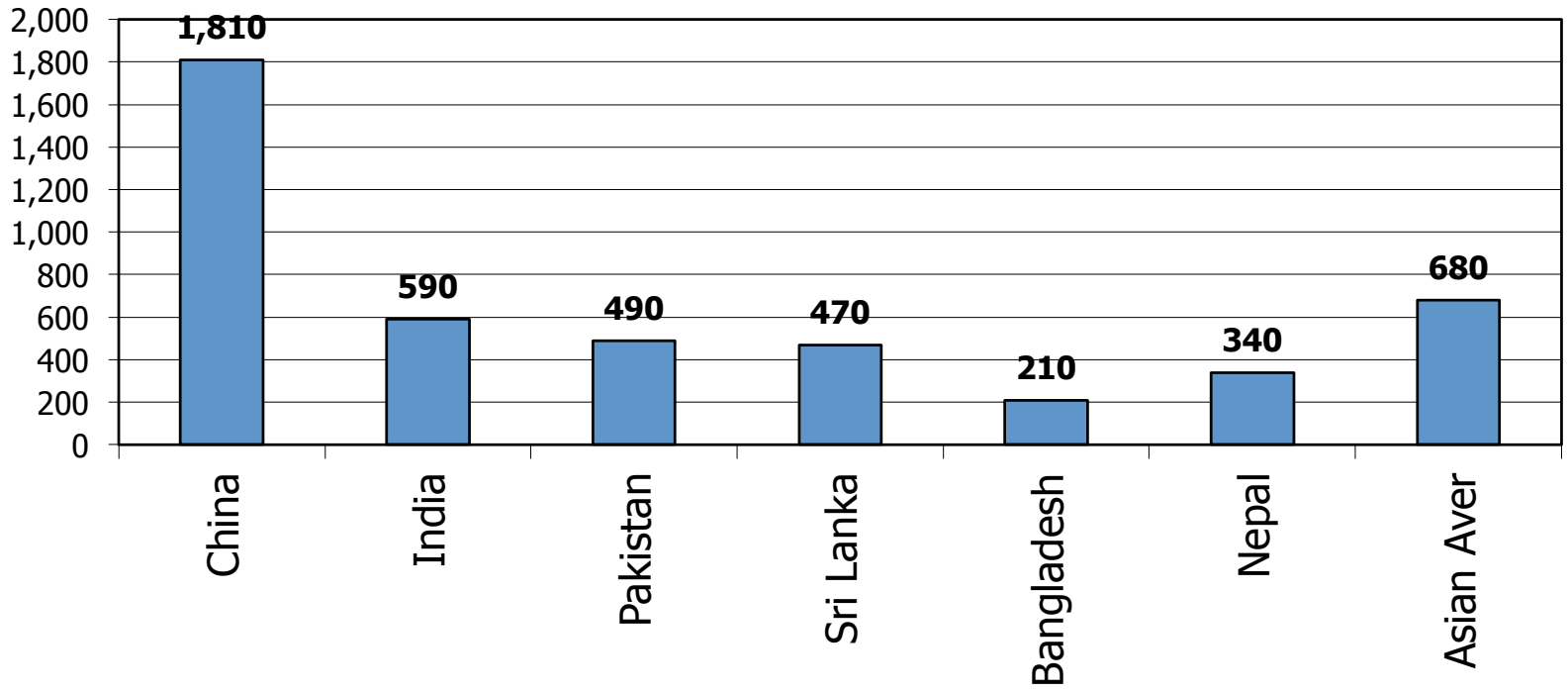
Physiographic Division-3

- **Mountain,**
- **Hills, and**
- **Terai**

OVERVIEW OF ENERGY SECTOR IN BASE YEAR 2010

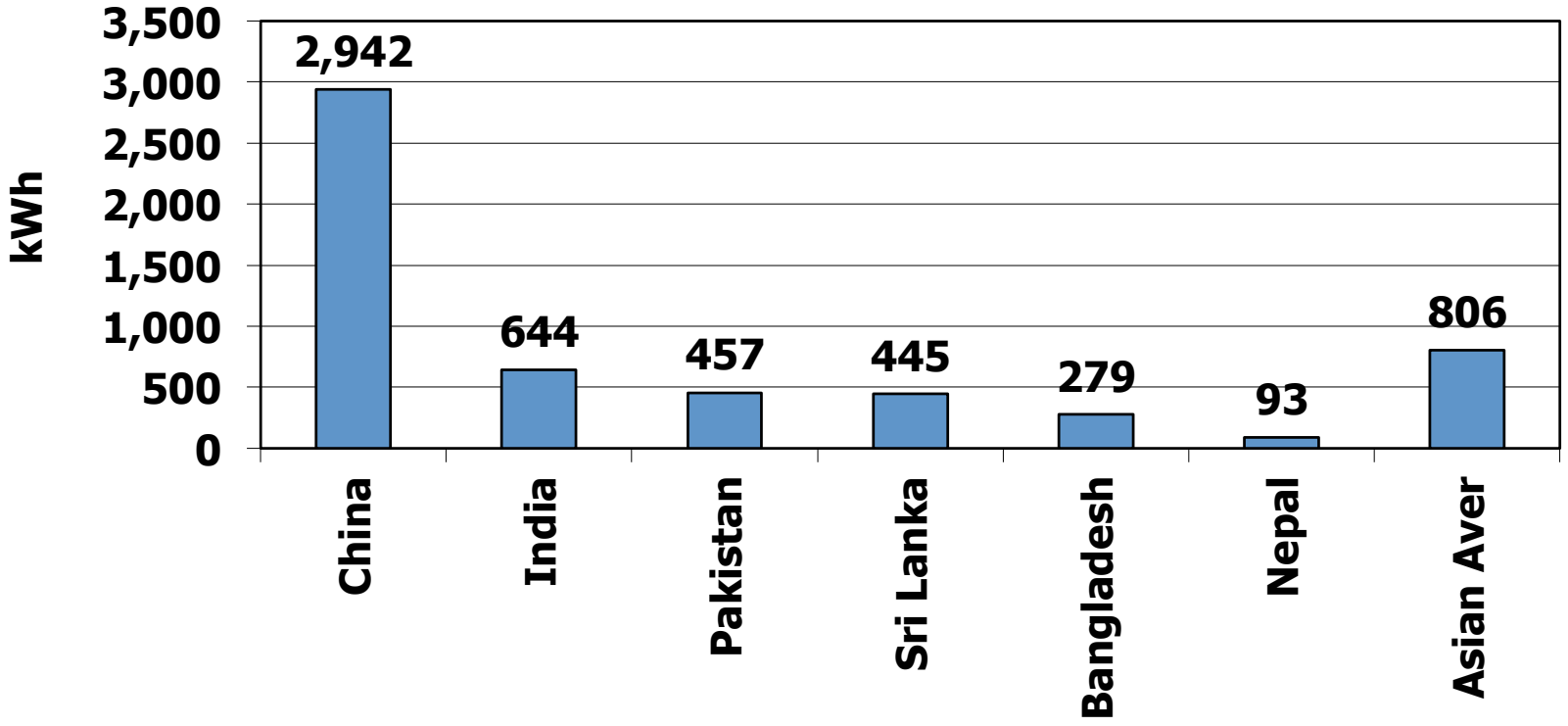
- Current status of traditional and commercial energy consumption
- Current status of power sector

Per Capita Primary Energy Supply in 2010 (kgoe)



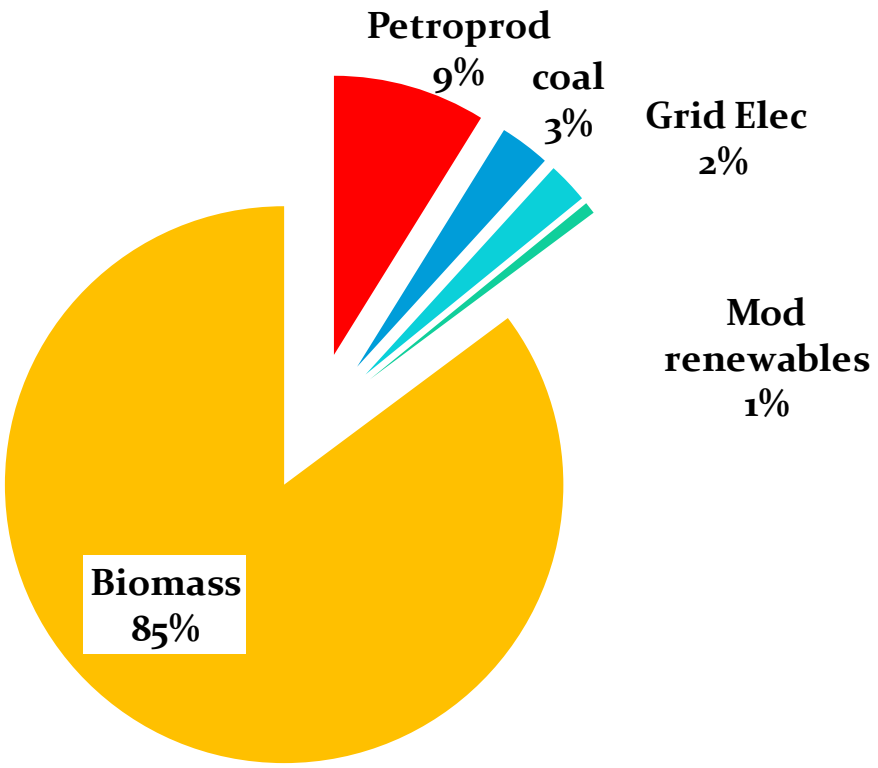
Key World Energy Statistics, IEA, 2012

Per Capita Electricity Consumption in 2010



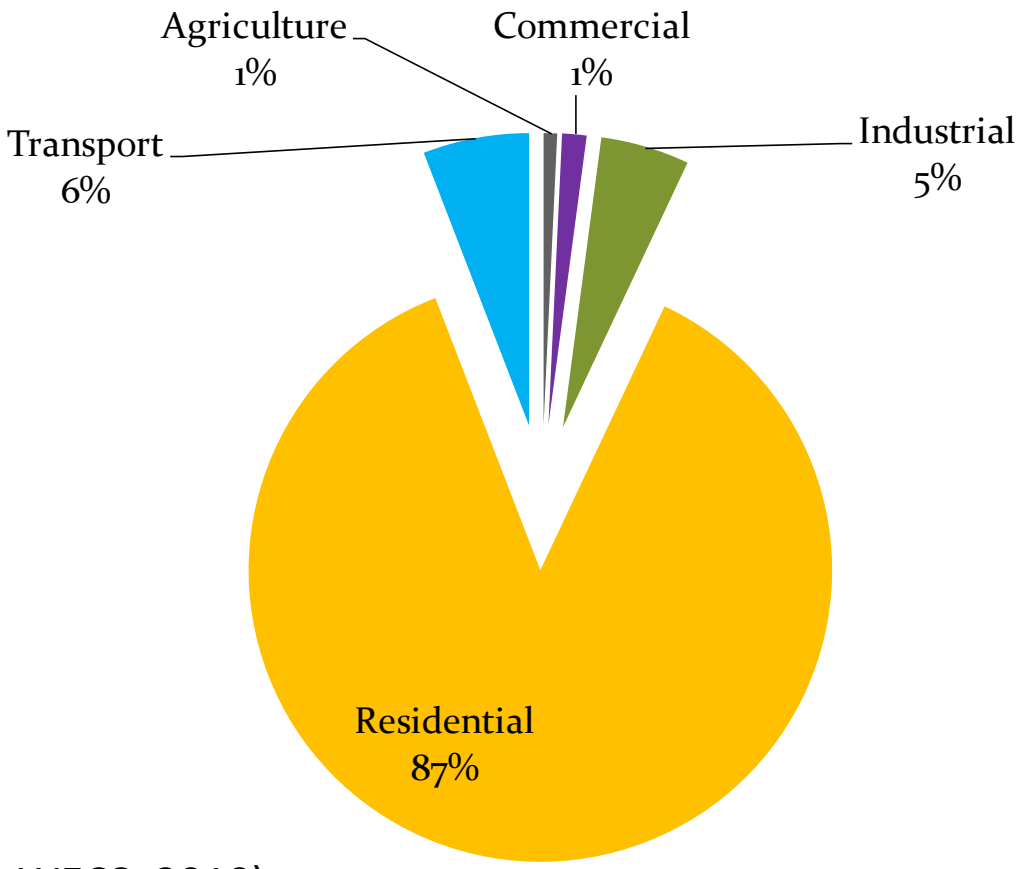
Key World Energy Statistics, IEA, 2012

Overview of energy sector in the base year 2010



Mix by Fuel type in 2010 (MOF, 2012; WECS, 2010)

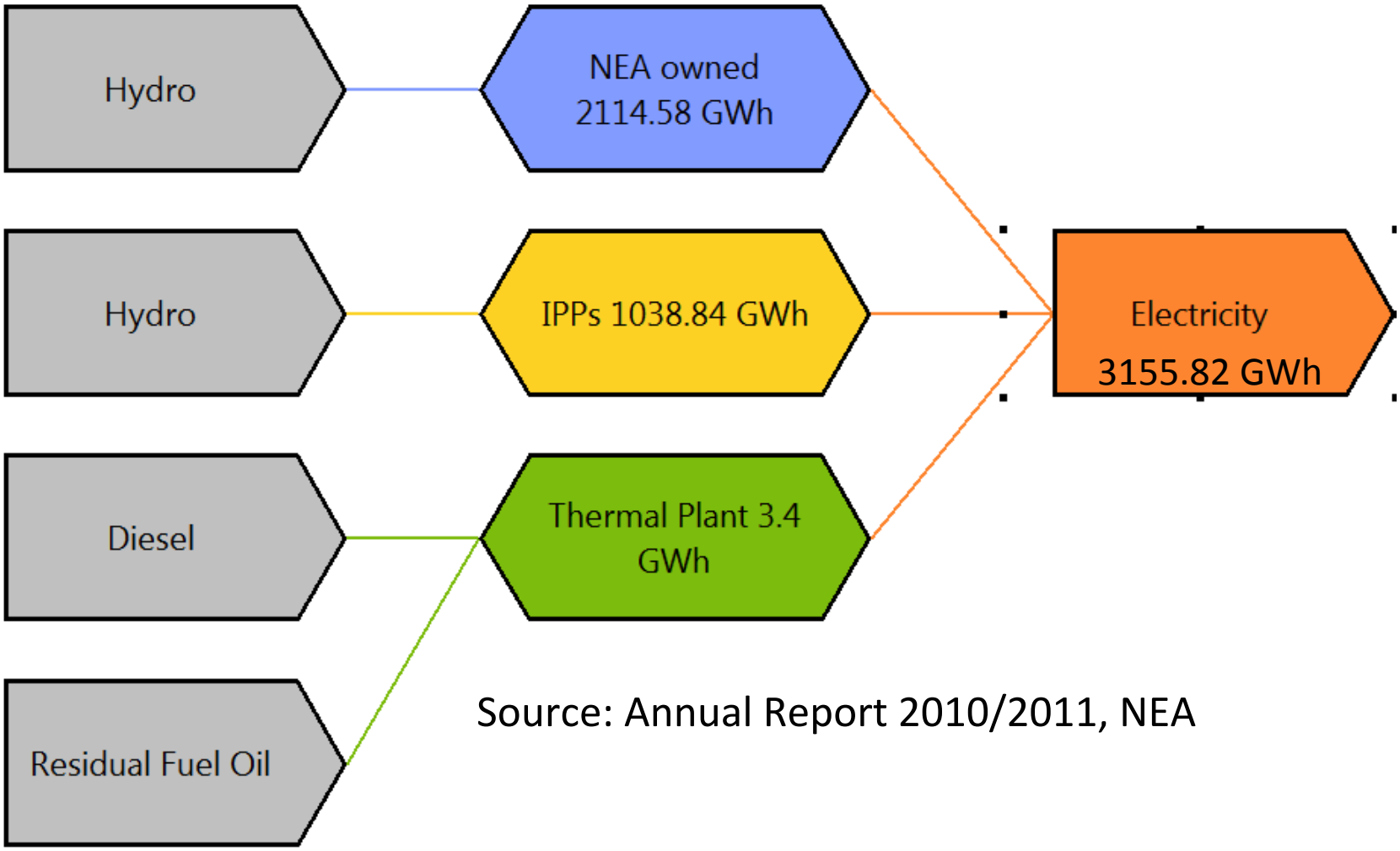
Energy consumption by Economic Sectors in 2010



(MOF, 2012; WECS, 2010)

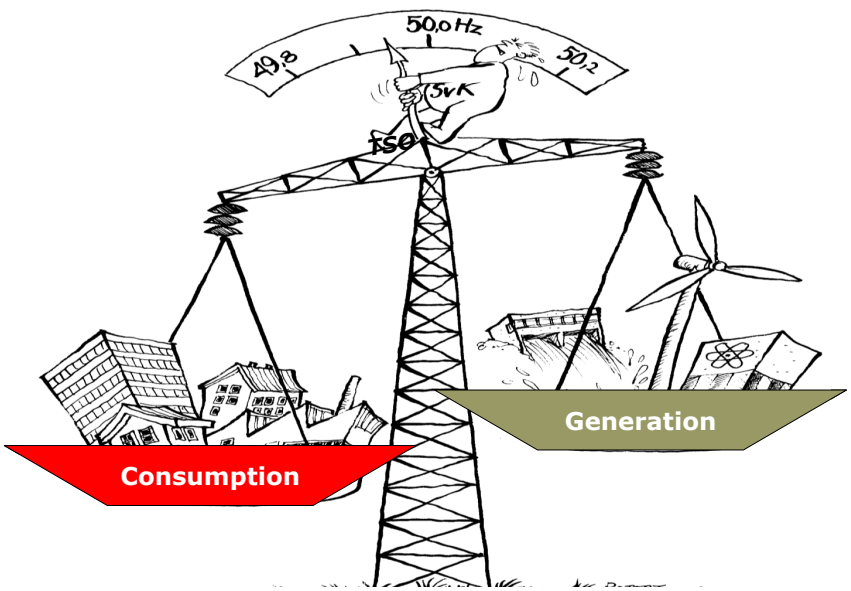
NEPAL'S POWER SECTOR AT A GLANCE

Nepal's Power Sector Mix in 2010/11



Source: Annual Report 2010/2011, NEA

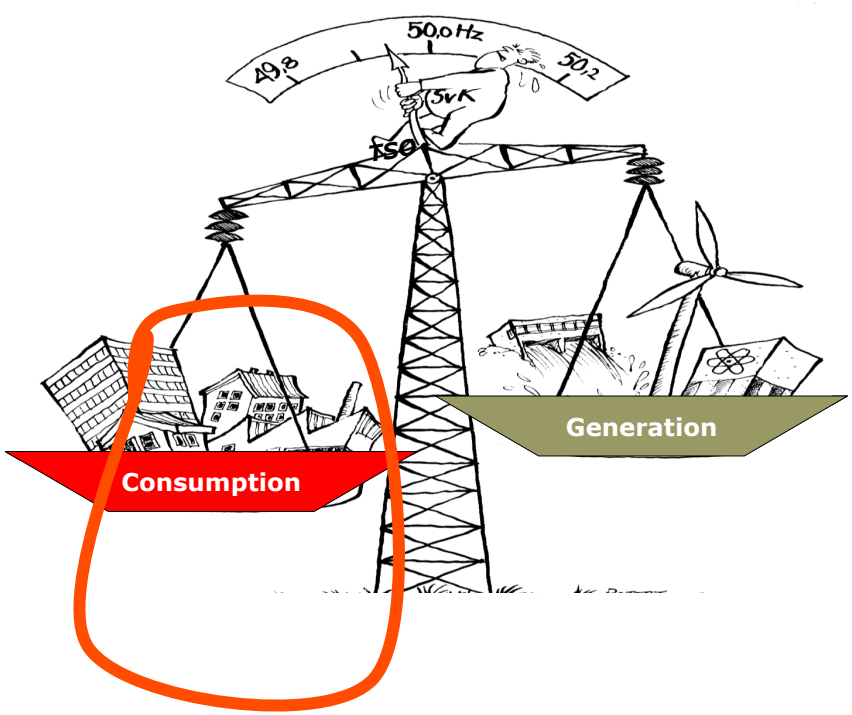
Power System: A balance



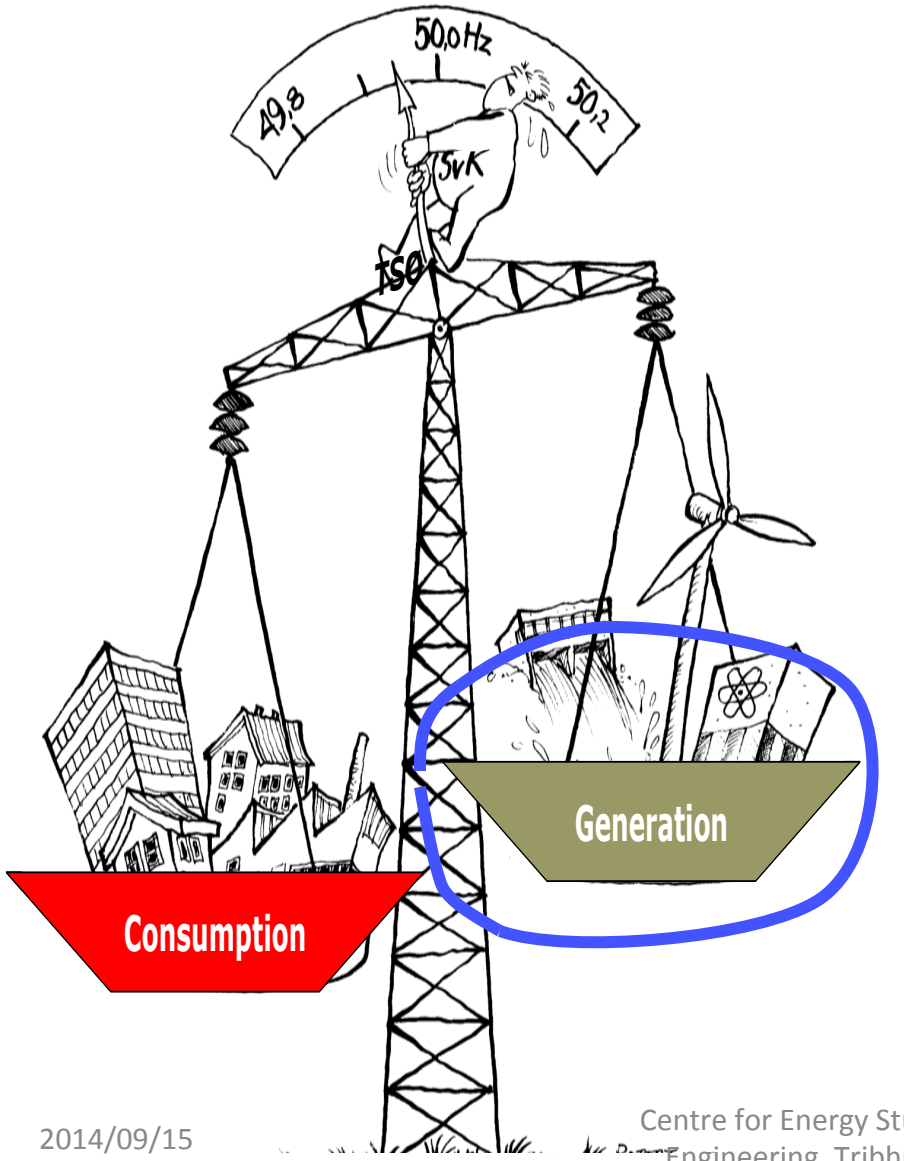
- **Like Balance**
- **Effort:** strike the balance
- **Unbalance:** frequency change
- **Severe unbalance:**
  - One of pans at ground
  - System collapse
- **To save from collapse:**
  - Some material thrown out
  - **load shedding**

DEMAND: Source and Nature

- **Source: Human activity**
- **Varies with:**
  - Level of human activity
  - Role of motion of earth
- **Earth Motions**
  - Spin on polar axis:
    - Time of day variation
  - Rotation:
    - Seasonal



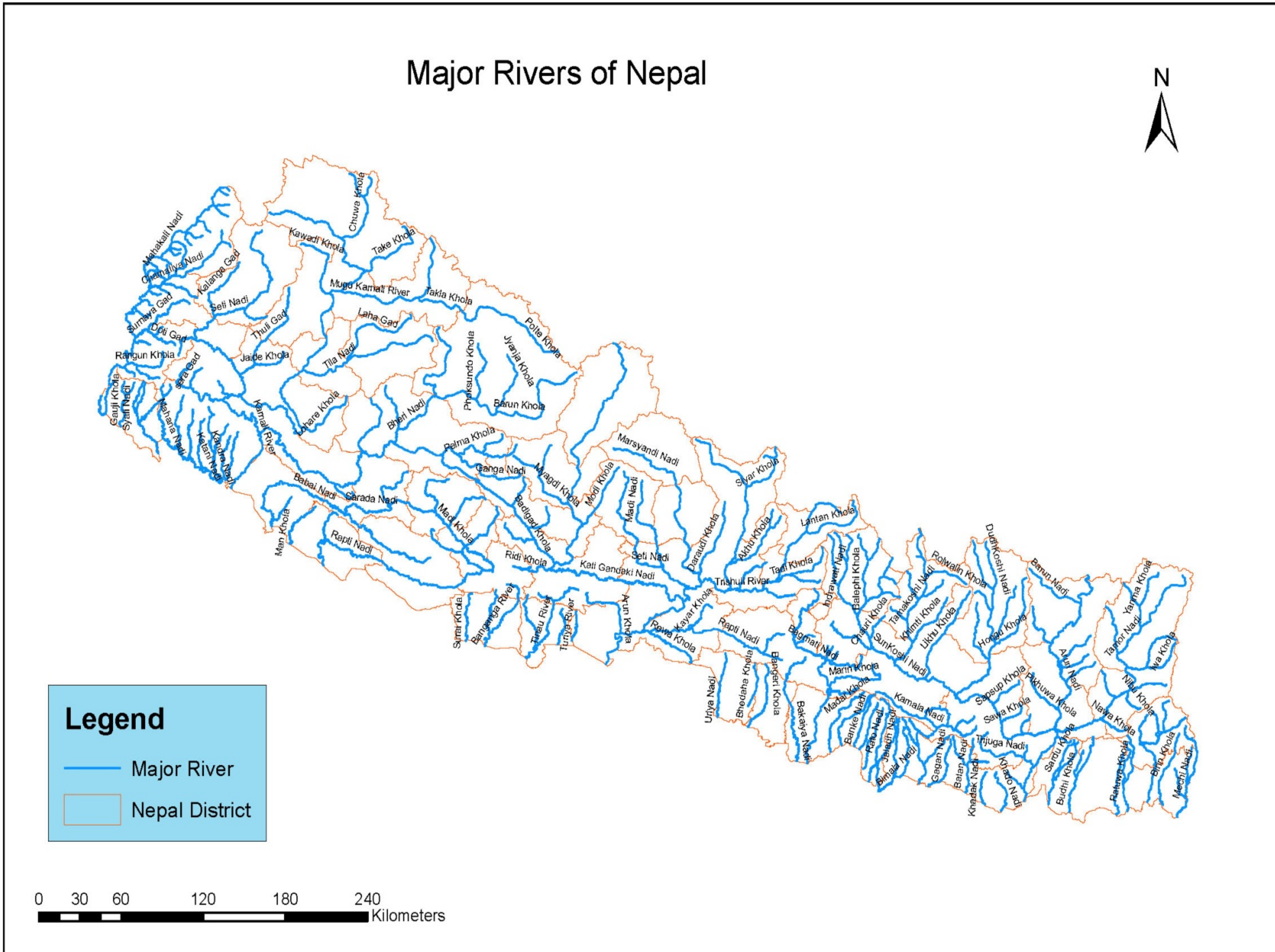
SUPPLY: Sources and Nature



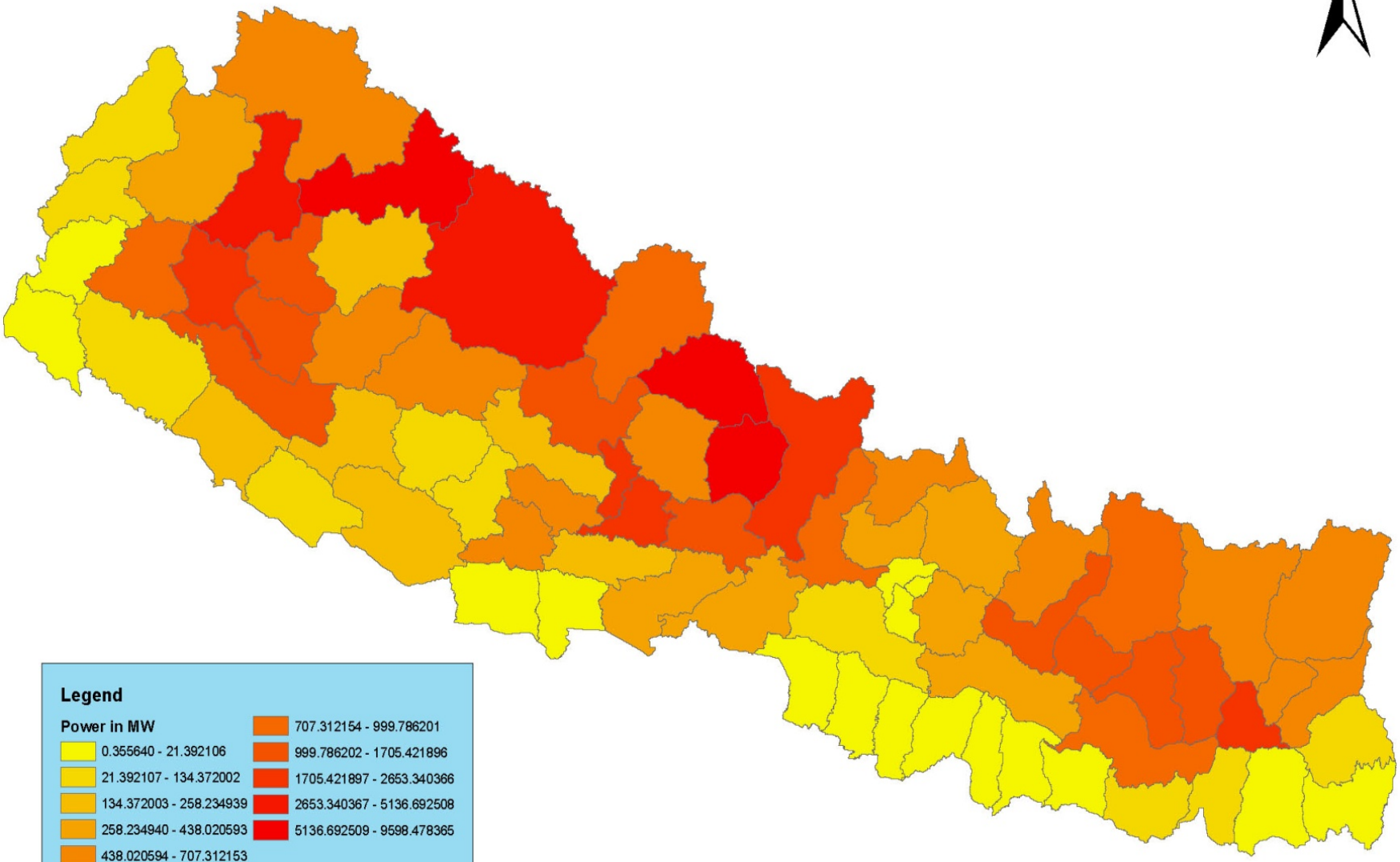
- **Sources**
  - **ROR or PROR hydro**
  - **Seasonal storage hydro**
  - **Thermal Power plants**
  - **Import**
- **Level of Supply varies**
  - **Seasonal more apparent**
- **Reason:**
  - **Rivers snow fed & rain fed**
  - **Natural snow reservoir**
  - **Underground reservoir**

Nepal's Water Resources

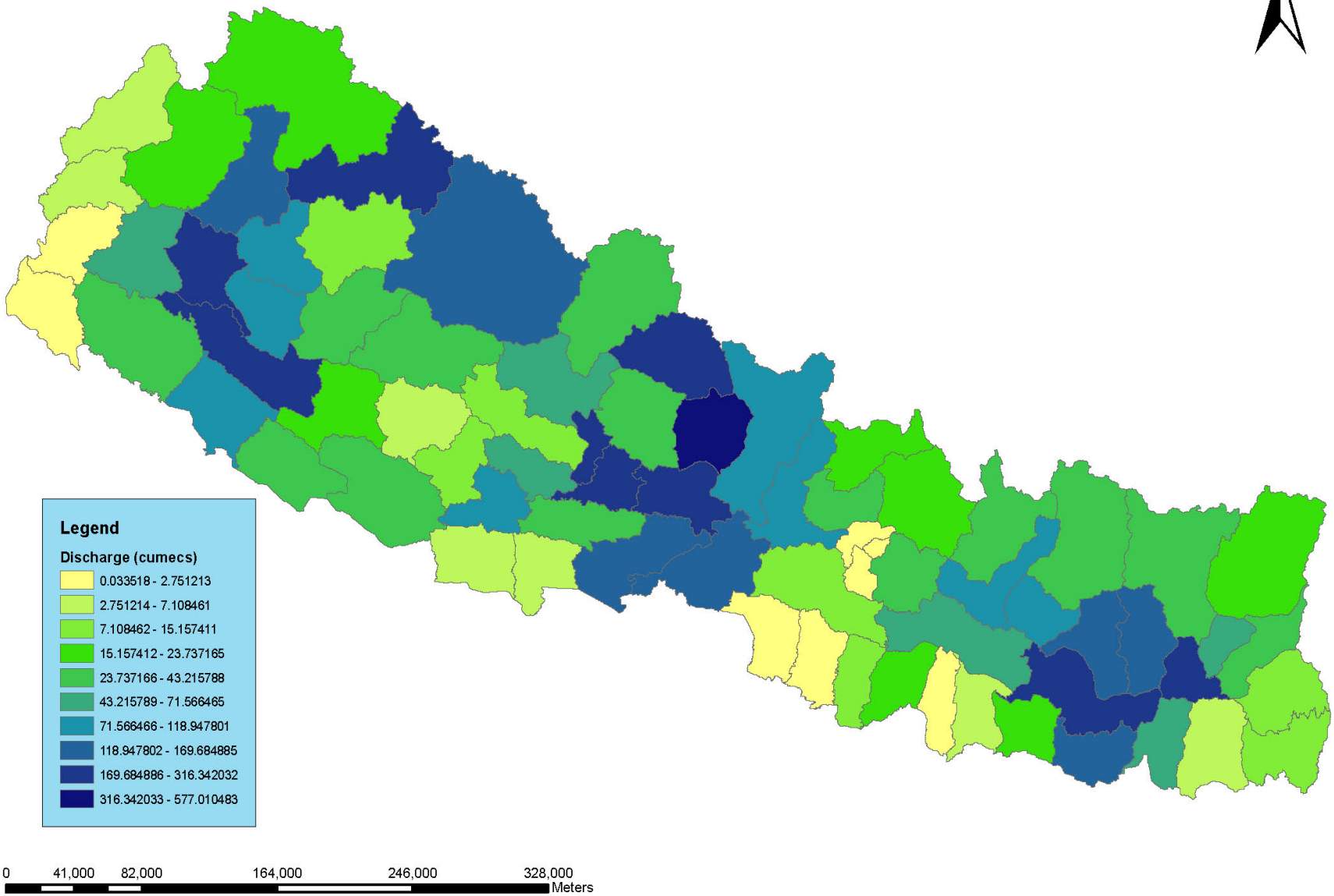
- About 6,000 rivers, with a total length of about 45,000 km with an annual discharge of 200 billion cubic meters of water are available in the country
- The potential of hydro-power in Nepal is said to be about **83,000 MW**.
- So far only about 750 MW have been connected to peak load system, which constitute about 2% of total energy supply


Major Rivers of Nepal
N
Legend
Major River
Nepal District
0 30 60 120 180 240
Kilometers
Mahakali Nadi
Chamaliya Nadi
Kalange Gad
Seti Nadi
Surnaya Gad
Doti Gad
Thuli Gad
Rangun Khola
Jaide Khola
Gauji Khola
Syali Nadi
Mahara Nadi
Ketani Nadi
Kandra Nadi
Karnali River
Kawadi Khola
Chuwa Khola
Take Khola
Mugu Kamali River
Takla Khola
Laha Gad
Tila Nadi
Lohare Khola
Bheri Nadi
Polte Khola
Phaksundo Khola
Jyanja Khola
Barun Khola
Pelma Khola
Ganga Nadi
Myagdi Khola
Babai Nadi
Sarada Nadi
Man Khola
Rapti Nadi
Madi Khola
Badigad Khola
Ridi Khola
Modi Khola
Marsyandi Nadi
Madi Nadi
Seti Nadi
Kali Gandaki Nadi
Daraudi Khola
Siyar Khola
Akhu Khola
Lantan Khola
Tadi Khola
Trishuli River
Sirrai Khola
Banganga River
Tinau River
Turiya River
Arun Khola
Kayar Khola
Rewa Khola
Rapti Nadi
Bagmati Nadi
Indrawati Nadi
Balephi Khola
Charauri Khola
Tamakoshi Nadi
Khimti Khola
Likhu Khola
SunKoshi Nadi
Rolwalin Khola
Dudhkoshi Nadi
Hongu Khola
Barun Nadi
Arun Nadi
Tamor Nadi
Yamma Khola
Iwa Khola
Nibu Khola
Urlya Nadi
Bhedaha Khola
Bangeri Khola
Bakaiya Nadi
Marin Khola
Madai Khola
Kamala Nadi
Sapsup Khola
Pikhuwa Khola
Sawa Khola
Nawa Khola
Banke Nadi
Rato Nadi
Jaladh Nadi
Bimala Nadi
Gagan Nadi
Betan Nadi
Khadak Nadi
Trijuga Nadi
Khado Nadi
Sardu Khola
Budhi Khola
Ratuwa Khola
Biring Khola
Mechi Nadi

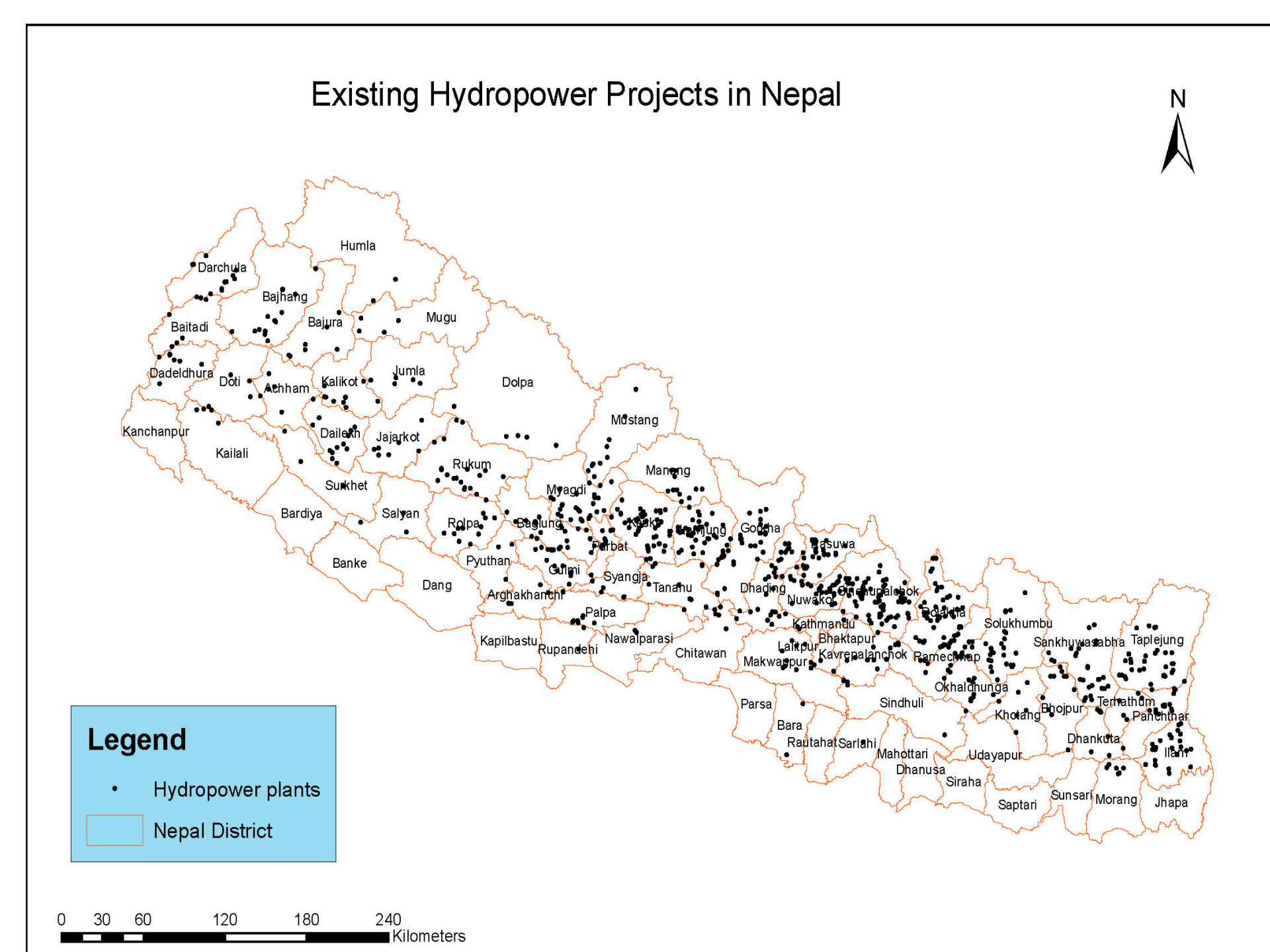
District wise Relative Hydropower Potential of Nepal



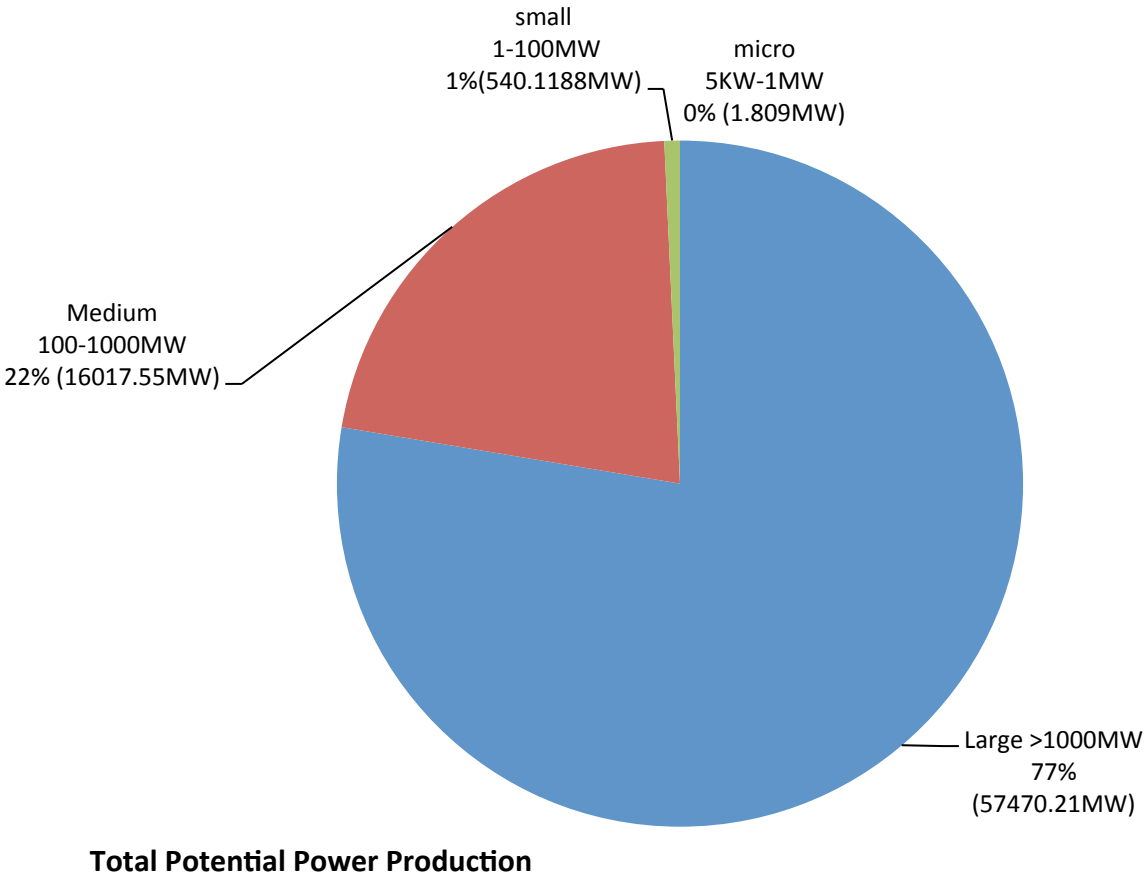
District wise available discharge of Nepal



Existing Hydropower Projects in Nepal



Total Power Potential in Group



Total Potential Power Production

Present Dry-season at a glance

- **Off peak**
  - Demand : 550 MW
  - Supply : 280 MW
  - Deficit ~ 50%
- **Evening Peak**
  - Demand: 1200 MW
  - Supply: 600 MW
  - Deficit ~ 50%
- **Morning Peak**
  - Demand: 610 MW
  - Supply : 310
  - Deficit ~ 50%

- Unequal distribution due to non synchronized grids will result in unequal load shedding.

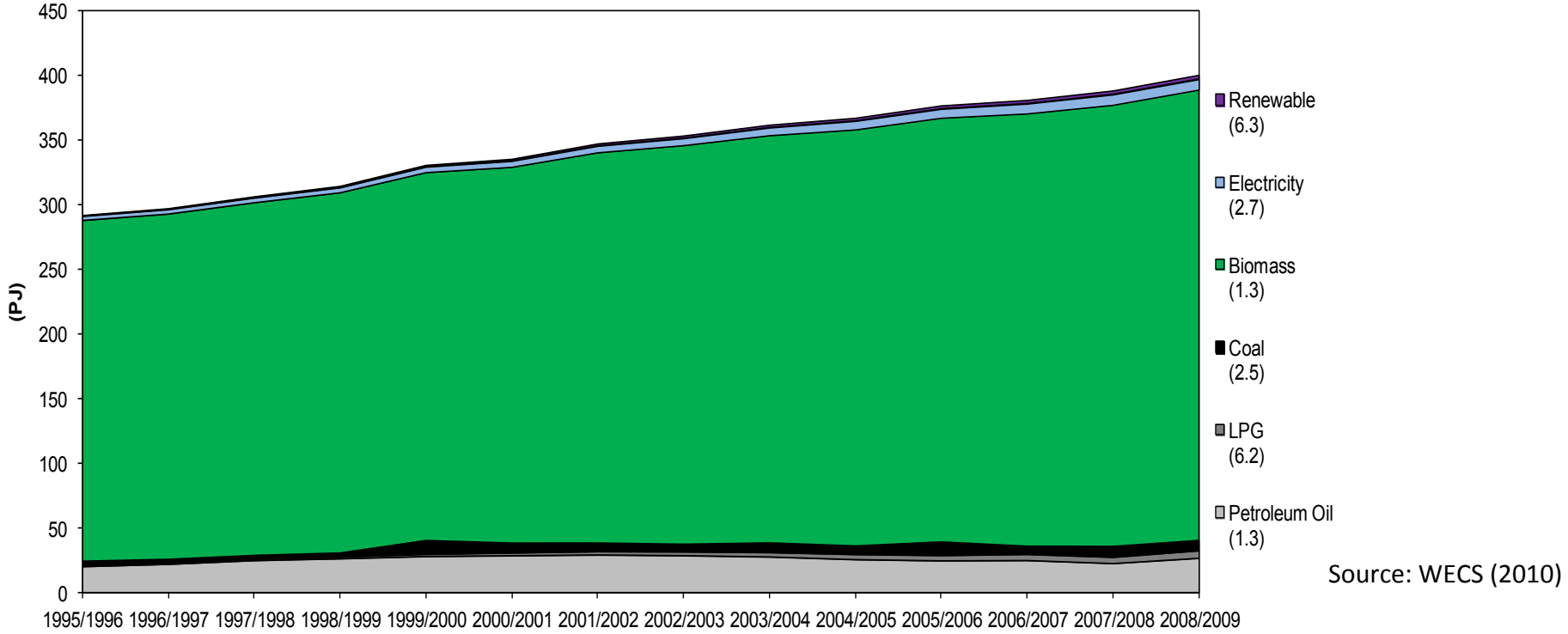
EVOLUTION OF ENERGY SECTOR IN NEPAL

Trend of Energy Consumption

Trend of Electricity Consumption

Trend of GHG Emission

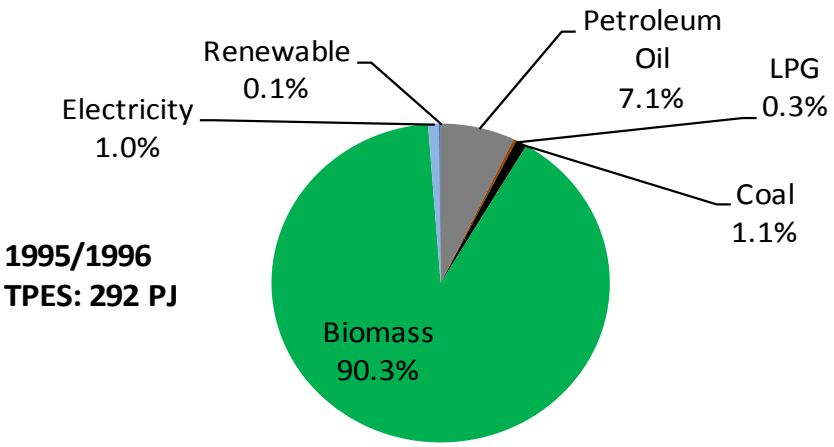
Energy Consumption Trend in Nepal during 1995/1996 to 2008/2009, PJ

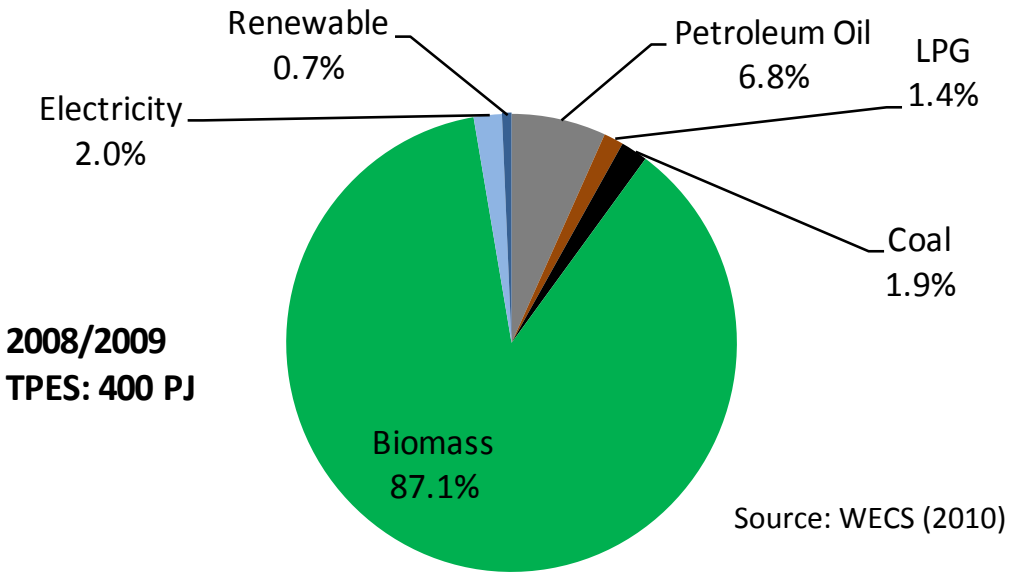


Source: WECS (2010)

- **Total energy consumption in the country was about 292 Peta Joule (PJ) in 1995/96**
- **it increased at the growth rate of 2.46% (during 1995/96 to 2008/09)**
- **use of fossil fuels consisting of petroleum products, LPG and coal has increased at the growth rate of 3.93% mostly due to rapid increase in LPG consumption**
- **electricity mostly from hydropower increase by 7.82%**
- **other renewable excluding hydro and traditional biomass grows by 15.19%**

Sectoral Energy Consumption Mix in Nepal during 1995/1996 to 2008/2009, PJ



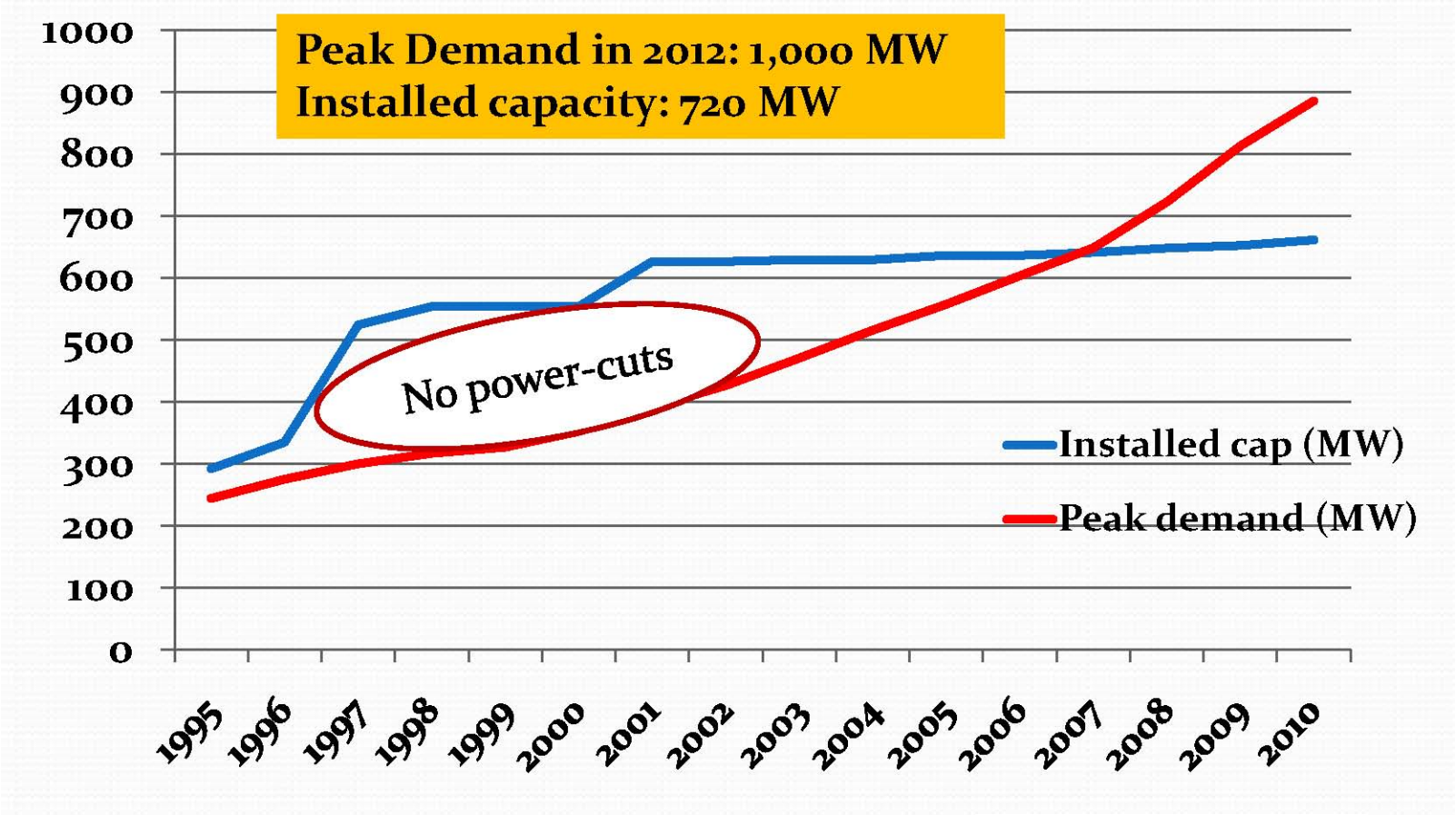


Source: WECS (2010)

- **Share of the residential sector shows decrease from 91.7% in 1995/1996 to 89.1% in 2008/2009**
- **Share of industrial sector shows decrease from 4% to 3.3%, whereas the share of the transport and commercial sectors indicates increase from 3% to 5.2% and 1% to 1.3% respectively**
- **Share of agriculture and and other sectors shows increase from 0.2% to 0.9% and 0.1% to 0.2% respectively during 1995/1996 to 2008/2009.**

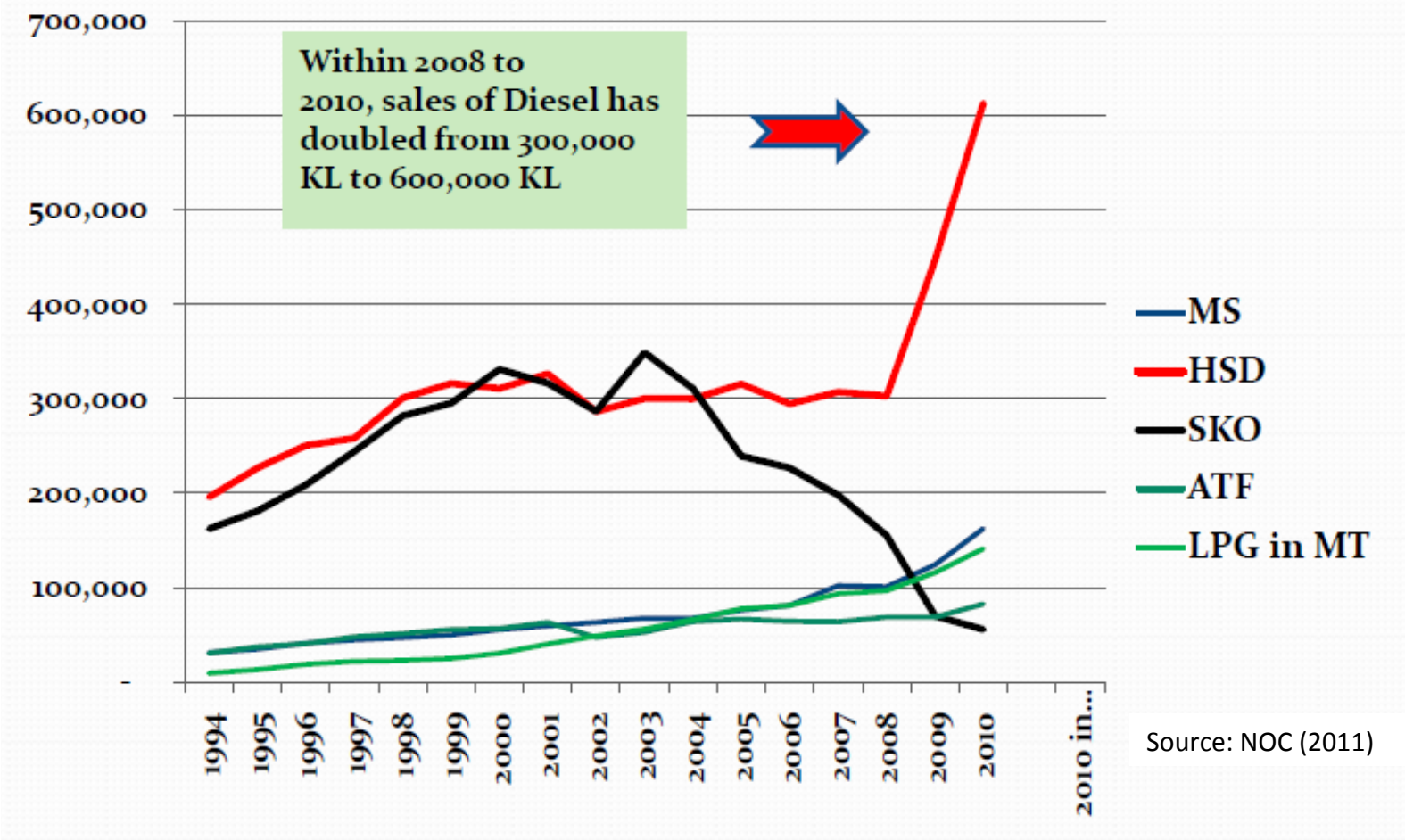
Power Capacity versus peak load

Power capacity development: historical trend



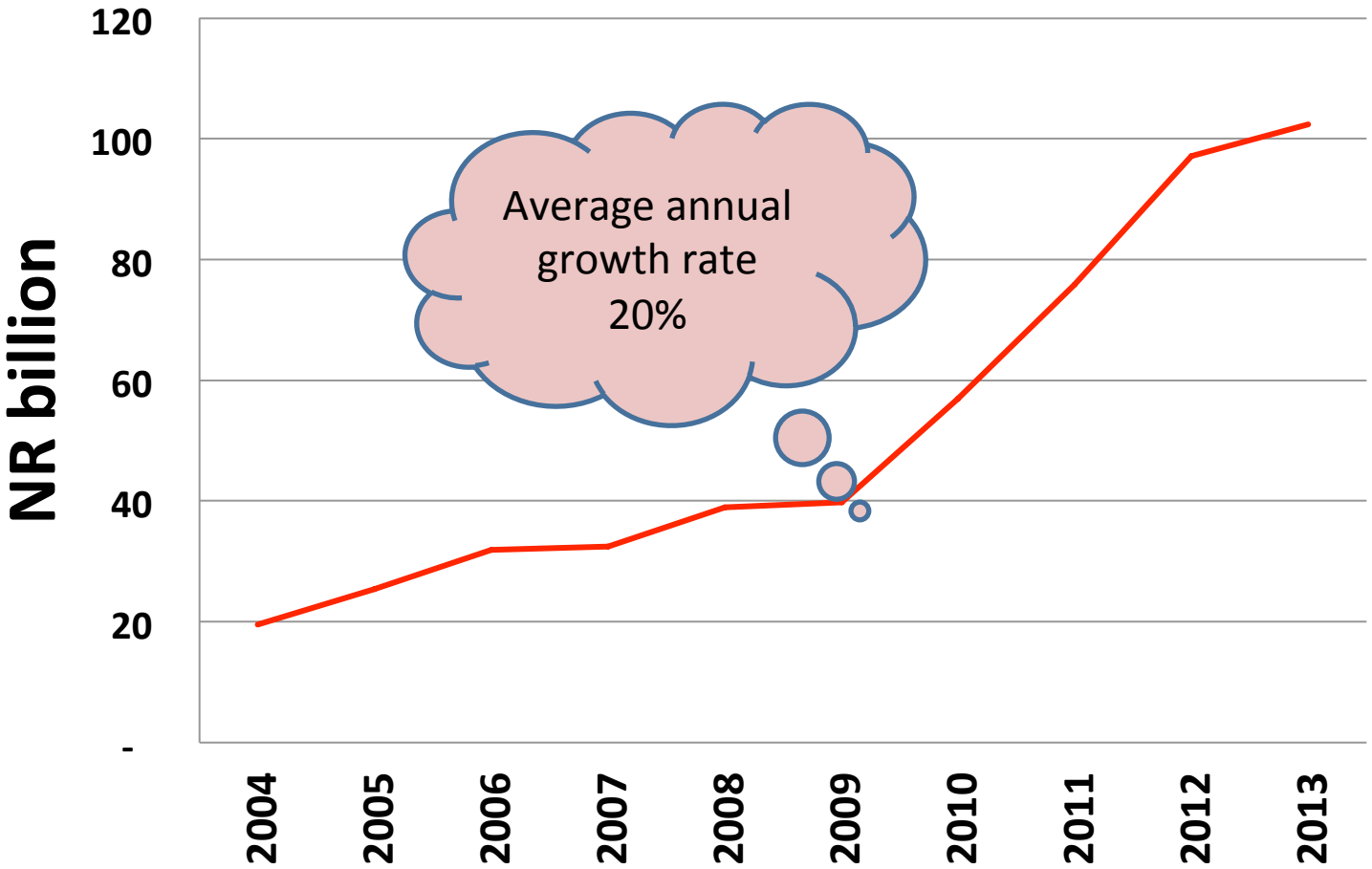
Source: NEA (2012)

Sales of Petroleum Products from 1994 to 2010



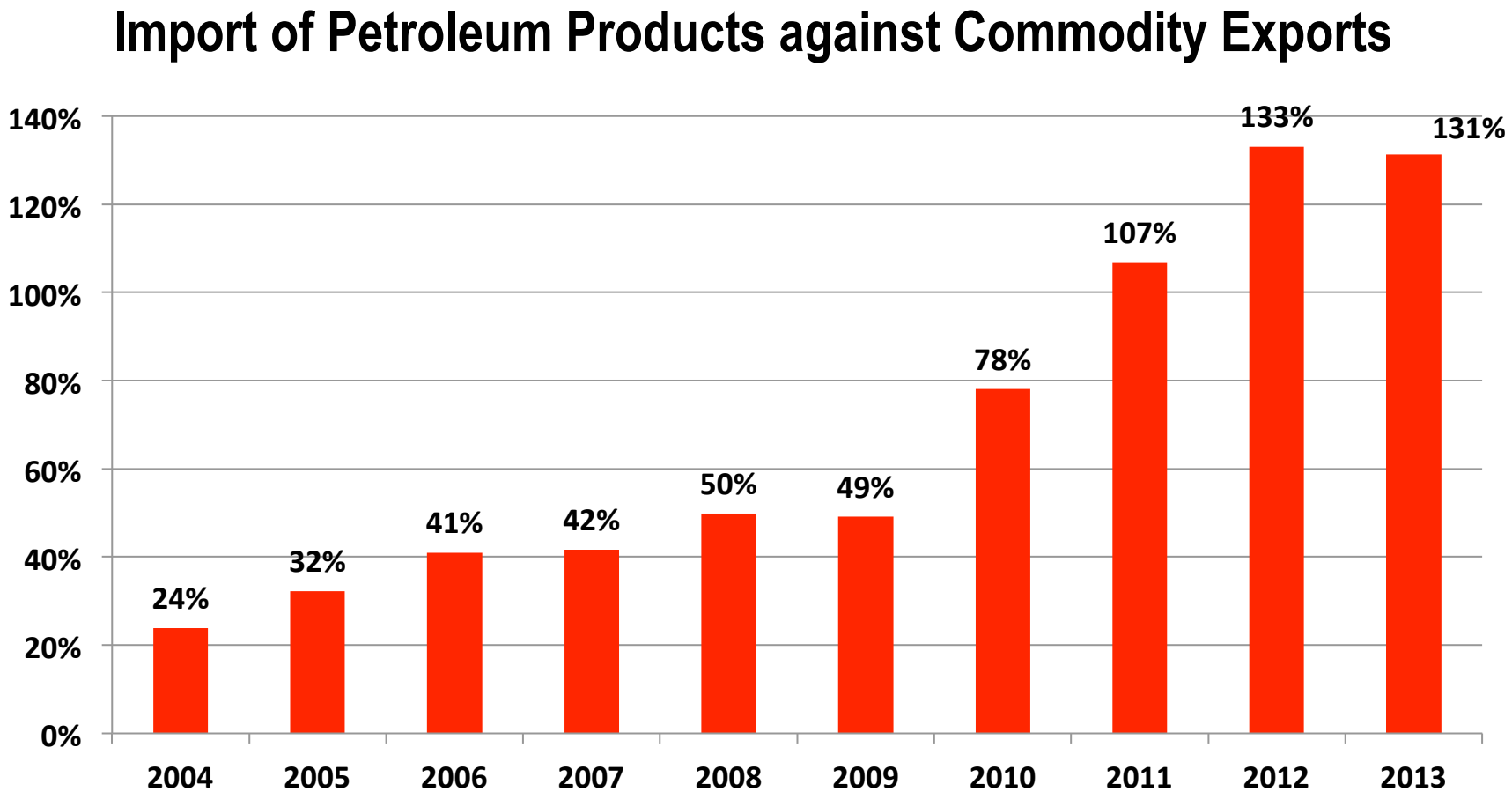
- **Unsustainable increase of diesel fuel (gen set) between 2008 – 2010 due to load shedding**

Petroleum Products Imports



Source: NOC (2014)

Economic burden from imported Fossil Fuels

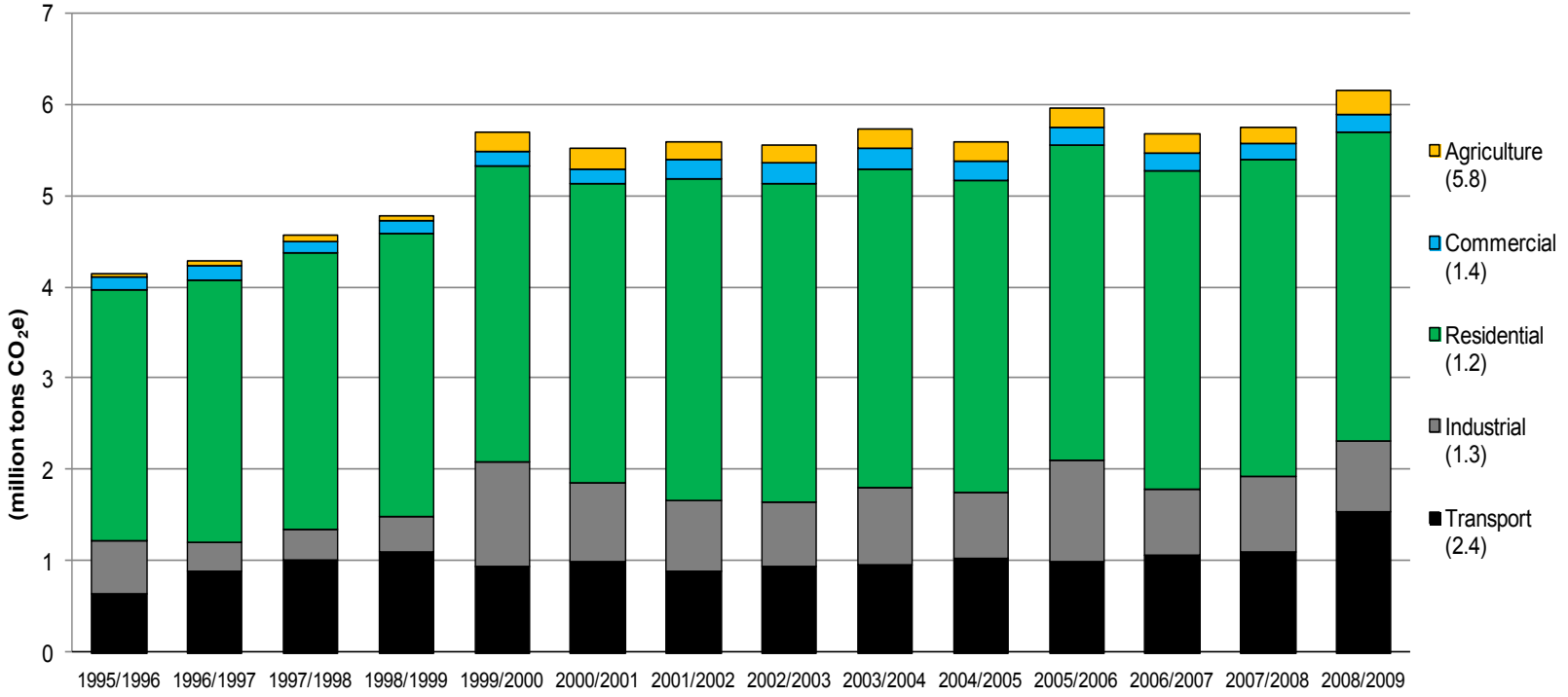


- **Economic Vulnerability increasing**

(Source: MOF, 2013; NOC, 2014)

GREEN HOUSE GAS EMISSION OF NEPAL

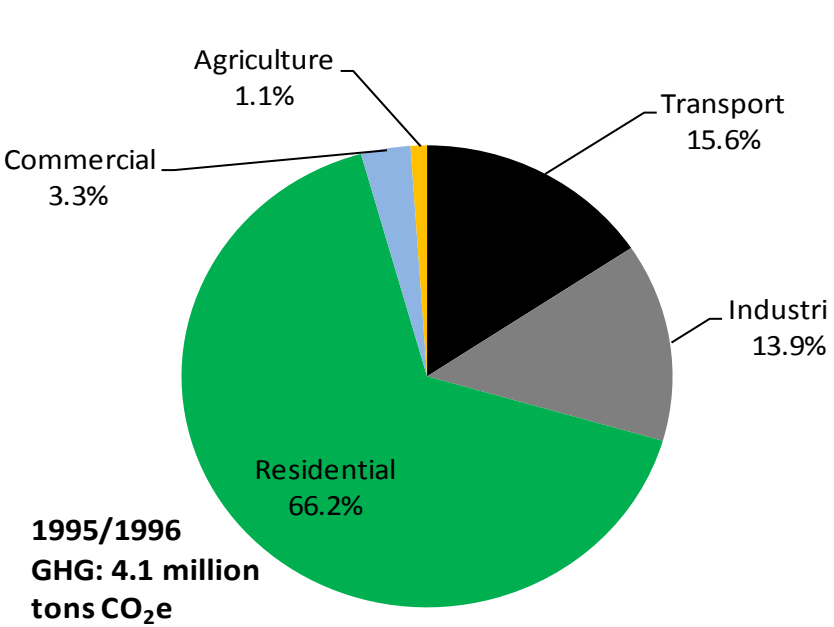
Trend of GHG Emissions during 1995/1996 to 2008/2009, million tons CO_2e

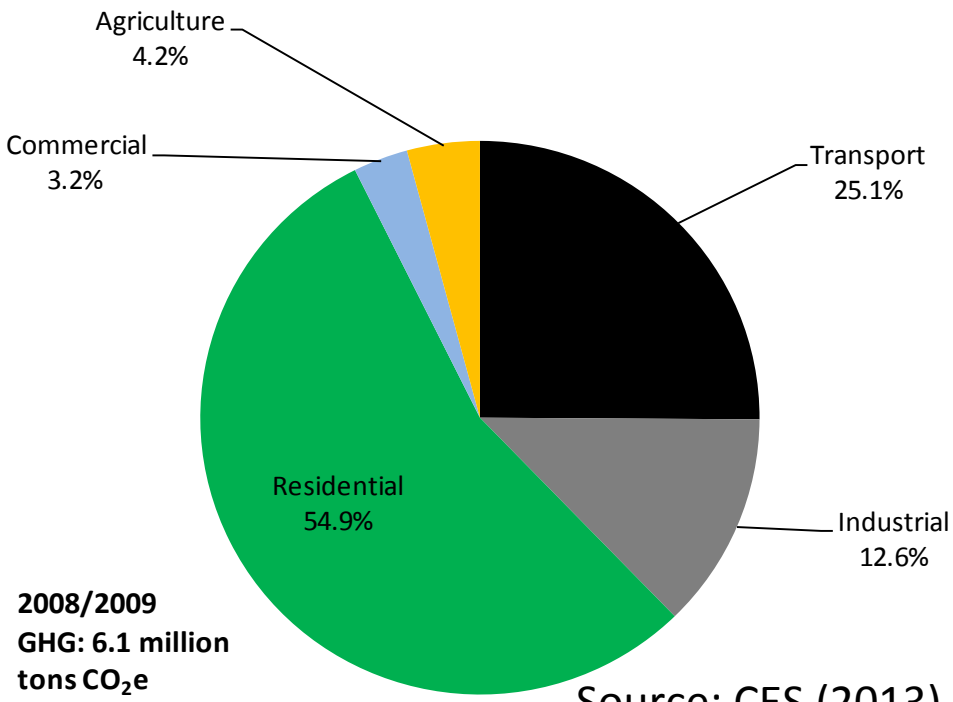


Source: CES (2013)

- **GHG emissions from energy use has increase by 48.3% from 4.1 million tons CO_2e (i.e., CO_2 equivalent) in 1995/1996 to 6.1 million tons CO_2e in 2008/2009**
- **The per capita GHG emission increases from 0.20 ton CO_2e/capita in 2005 to 0.24 ton CO_2e/capita in 2030.**

Sector wise GHG Emissions during 1995/1996 to 2008/2009, million tons CO_2e





Source: CES (2013)

- **In 1995/1996, residential sector dominates in the share of GHG emission with over 66.2%, followed by transport sector with 15.6% share and industrial sector with 13.9% share.**
- **However, sectoral contribution of GHG emission changes significantly in 2008/2009, with residential sector constituting 54.9%, transport sector consisting of 25.1% and Industrial sector constituting 12.6%.**

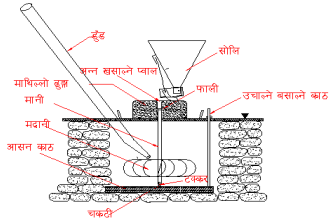
RENEWABLE ENERGY , GHG MITIGATION POTENTIAL AND COST IN NEPAL

Renewable Energy Potential and Progress in Nepal

Micro-hydro (Potential 100MW & Progress- 0.13million hhs:13MW)

HHs Biogas (Potential 1.1 million & Progress-0.22 million hhs)

Wind (Potential 3000MW & Progress-Pilot projects)

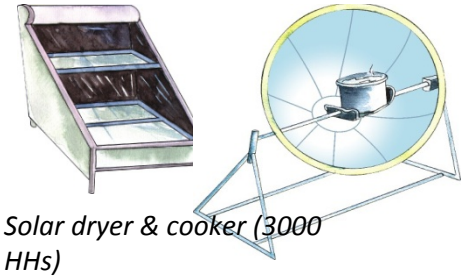


IWM (Potential 25,000 & Progress-0.2million hhs:6200Systems)

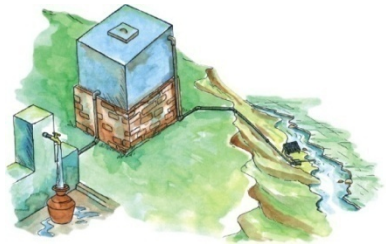
ICS (Potential 2500,000 & Progress-400,000 hhs)

Biofuel (Potential 1100,000 tons & Progress-

SHS (Potential 4.5 kWh/m2/day & Progress-0.2 million hhs)



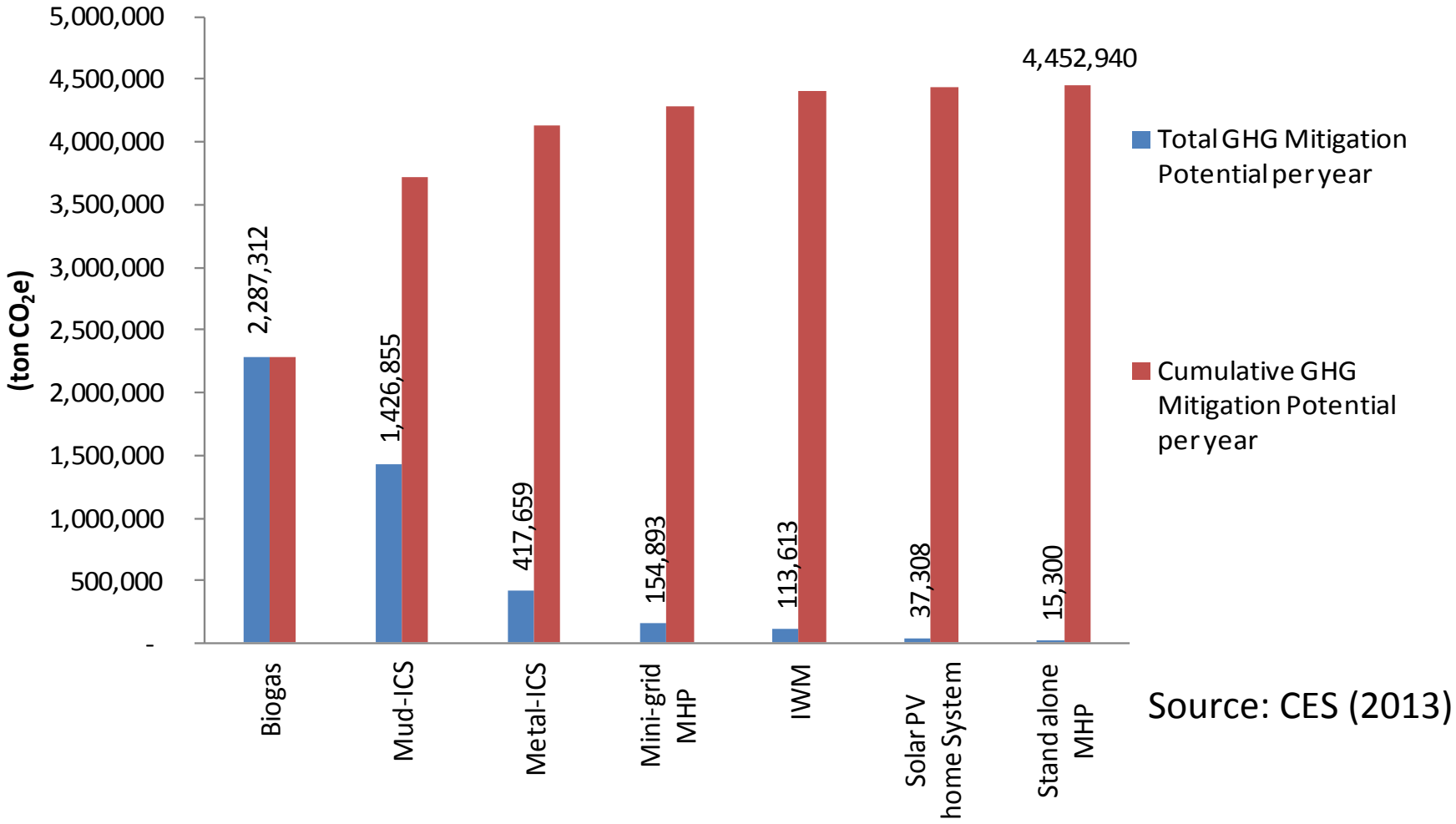
Solar dryer & cooker (3000 HHs)



Institutional Solar System/Solar water pumping (200, 000 HHs)

(*Source: AEPC 2010*)

Theoretical GHG Mitigation Potential of RET in Nepal, ton CO_2e



Source: CES (2013)

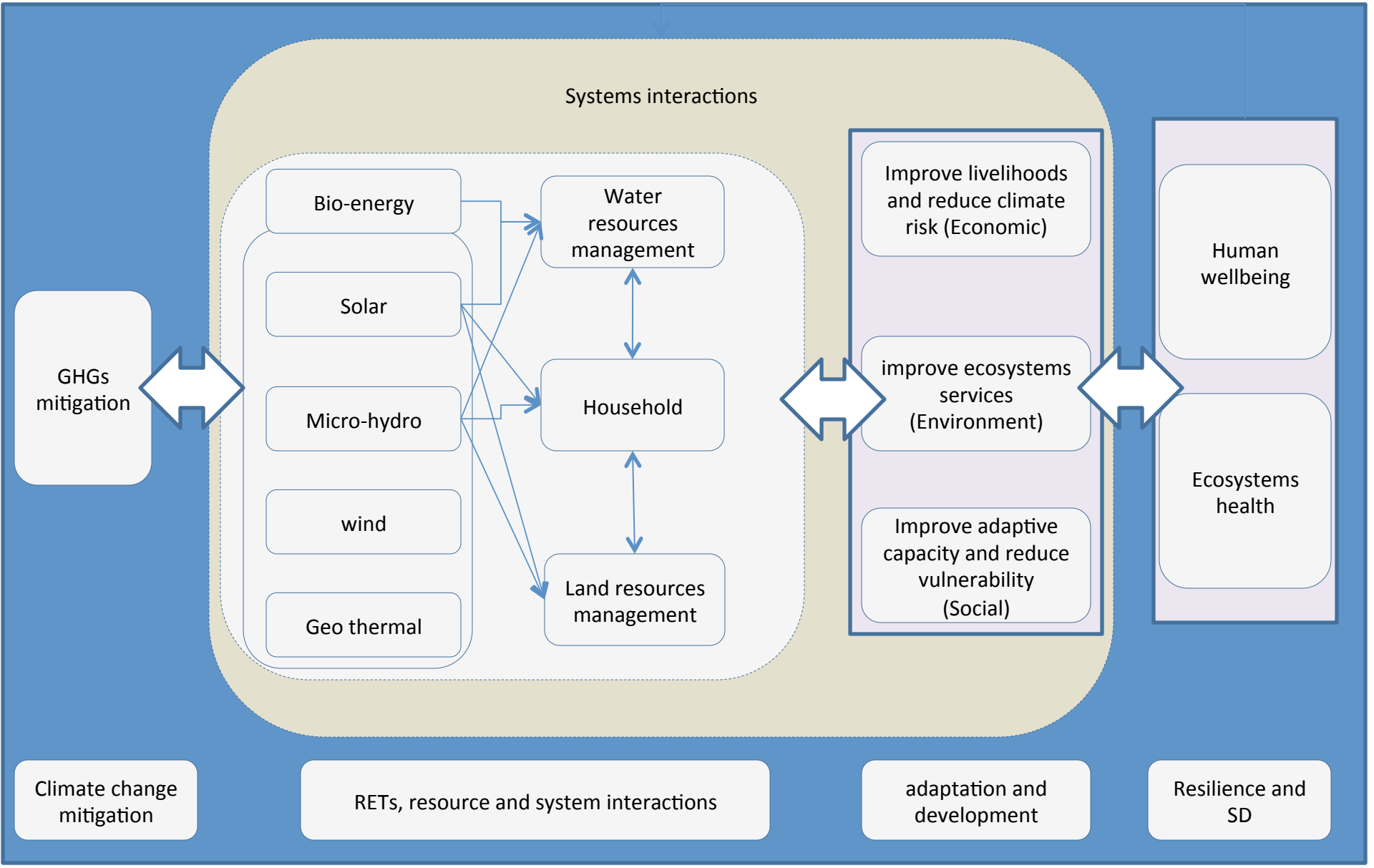
- **4.45 million tons of CO2e of the GHG emission can be mitigated per year if all the remaining technical potential of deploying seven major RET options consisting of biogas, improved water mill, stand-alone micro-hydro plants, mini-grid micro-hydro plants, solar PV home systems, ICSs were installed after 2012.**

Techno-economic GHG Mitigation Potential based on existing infrastructure of RET in Nepal, ton CO_2e

RET	Capacity/ unit	Average Installation per year	2013	2017	2020	2025	2030	Cumulative GHG Mitigation Potential (2013-2030)
Biogas	6 m3 unit	19932	55,412	277,059	443,295	720,355	997,414	9,475,433
Mud-ICS	two pot hole family size unit	59906	113,699	568,494	909,590	1,426,855	1,426,855	17,429,631
Metal-ICS	two pot hole family size unit	2549	7,256	36,280	58,047	94,327	130,606	1,240,761
MHP-Stand alone	per kW	291	653	3,264	5,223	8,487	11,752	111,642
MHP-Mini grid	per kW	2325	5,423	27,116	43,386	70,502	97,618	927,370
IWM	per kW	1079	5,385	26,924	43,078	70,002	96,925	920,789
Solar PV home system	35 watt peak unit	48313	8,348	37,308	37,308	37,308	37,308	605,797
Total			**196,176**	**976,445**	**1,539,927**	**2,427,835**	**2,798,478**	**30,711,424**

- **30.7 million tons of CO2e of the cumulative GHG emission reduction during 2013 to 2030 from seven major RET options installed after 2012.**

RETs, Mitigation, adaptation and development – Functional relations



Source: various sources and researcher's analysis

Conclusion

- There is a strong relationship between energy and development.
- The development must be sustainable because there is undeniable symbiosis that binds energy and climate change together. These are two sides of the same coin.
- Through clean and renewable energy technologies a significant contribution can be made to reduce the climate change impact of nations.
- Use of renewable energy must be up-scaled.

Climate Resilient Energy Planning

- Necessary to target measures for bringing change in energy generation and use.
- Vulnerability can be addressed through legal and policy measures and subsidies can help vulnerable groups to adopt new technologies.
- Resilience can be increased through alternative energy, energy-based livelihood enhancement and access to markets.
- Adaptive capacity can be enhanced through exposure to technology, increased awareness, knowledge sharing and networking.

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