International Workshop: **Energy, Environment and Ecosystems (3E) Nexus**
Initiative for Sustainable Development in Asian Countries

14th to 15th January 2016

Challenges of Nepalese Hydropower Development: Impact of Recent Natural Disaster and Climate Change Issues

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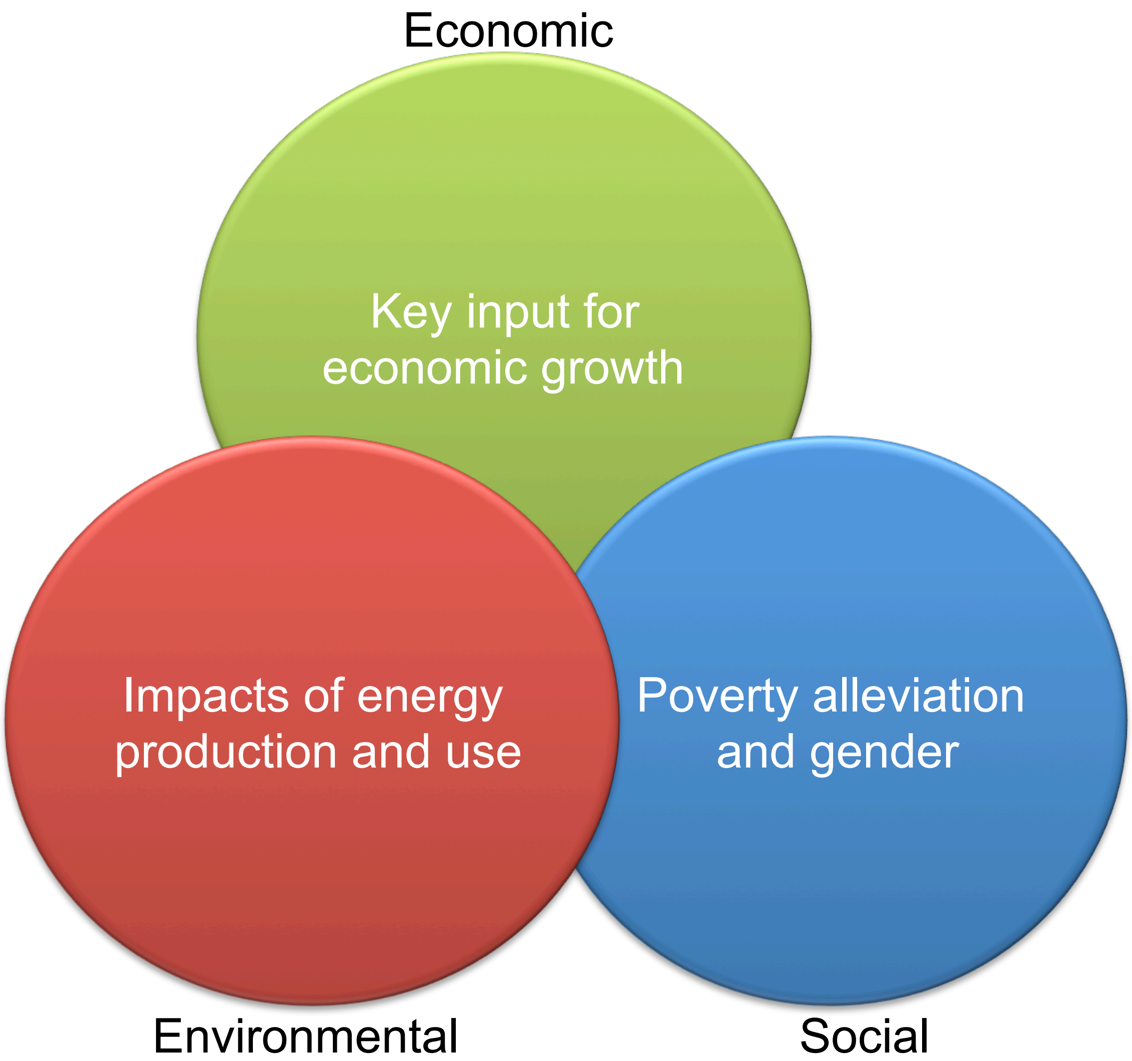
Energy for Sustainable Development



Nepal
Demographics

Nepal, officially the Federal Democratic Republic of Nepal, is a landlocked country located in South Asia.

Population: 27.8 million (2013) World Bank

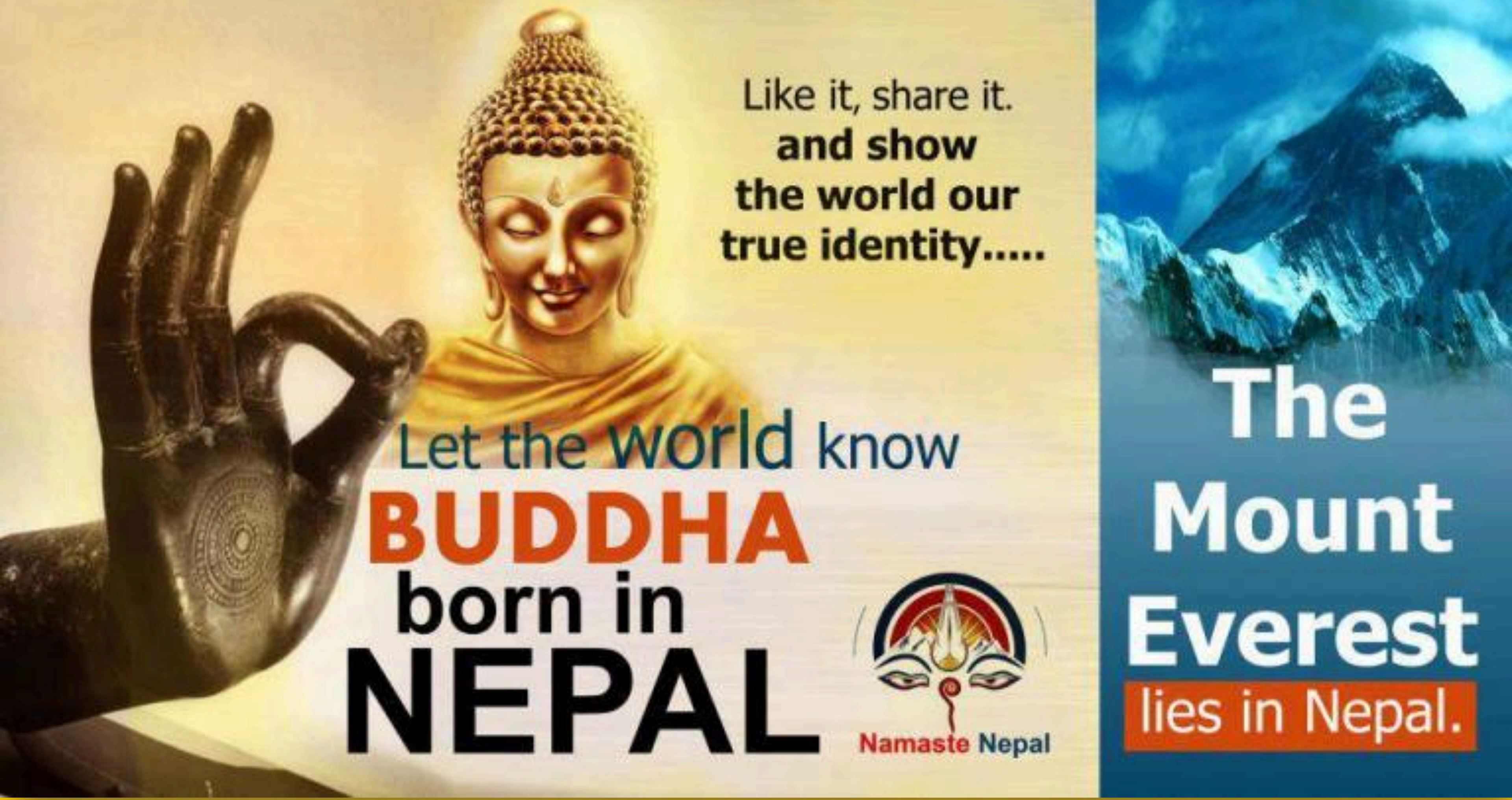
GNI per capita: 2,260 PPP dollars (2013) World Bank

Population growth rate: 1.2% annual change (2013) World Bank

Life expectancy: 67.98 years (2012) World Bank

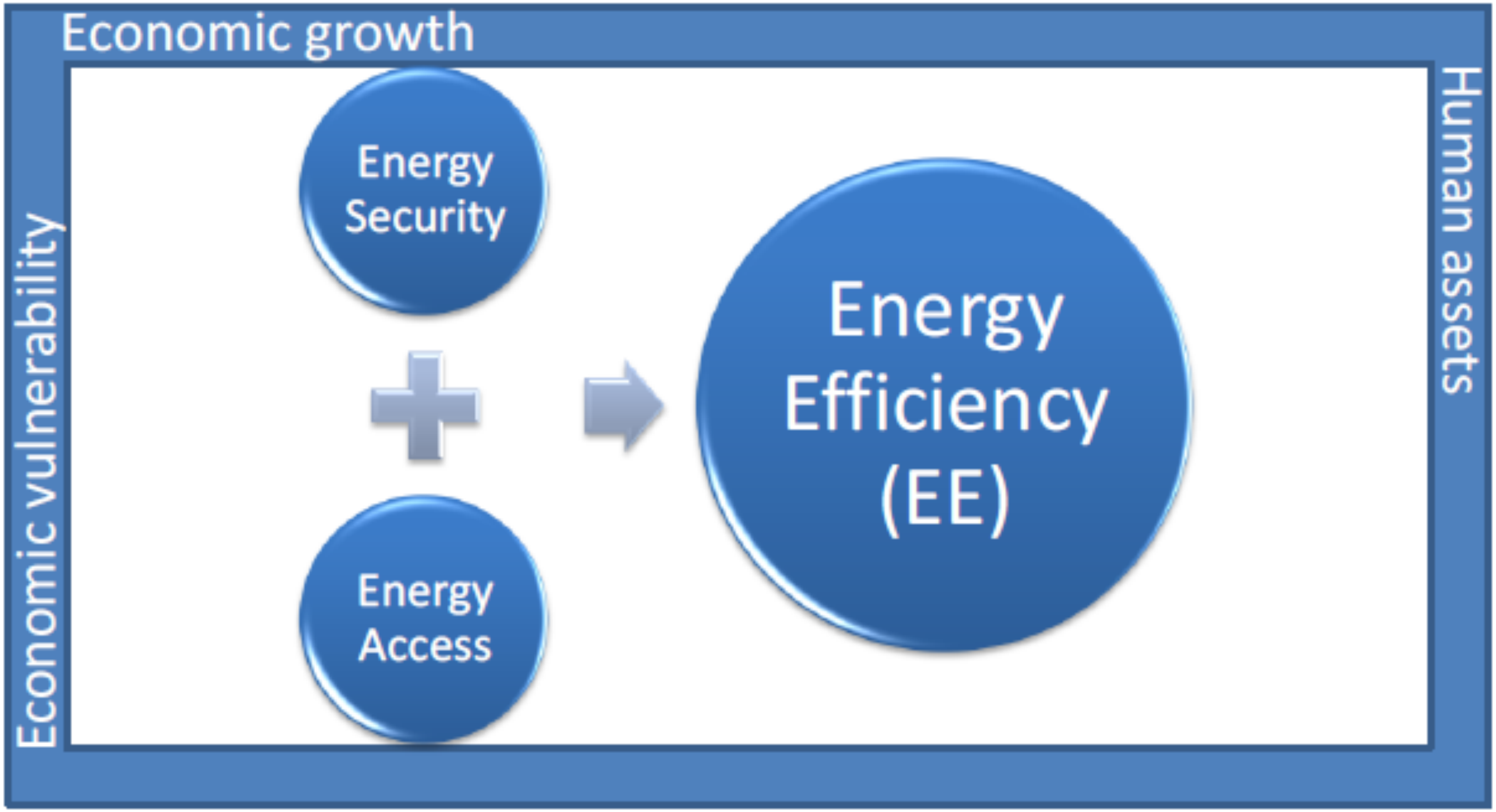
Fertility rate: 2.39 births per woman (2012) World Bank

Official language: Nepali


Like it, share it.
and show
the world our
true identity.....
Let the world know
BUDDHA
born in
NEPAL
Namaste Nepal
The
Mount
Everest
lies in Nepal.


KATHMANDU
NEPAL

Graduating up from Least Developing Countries to Developing by 2022



Energy Resources of Nepal:

Non Renewable

- Exploration of petroleum reserves is in progress
- So far no achievement
- So far 100% petroleum products imports from abroad

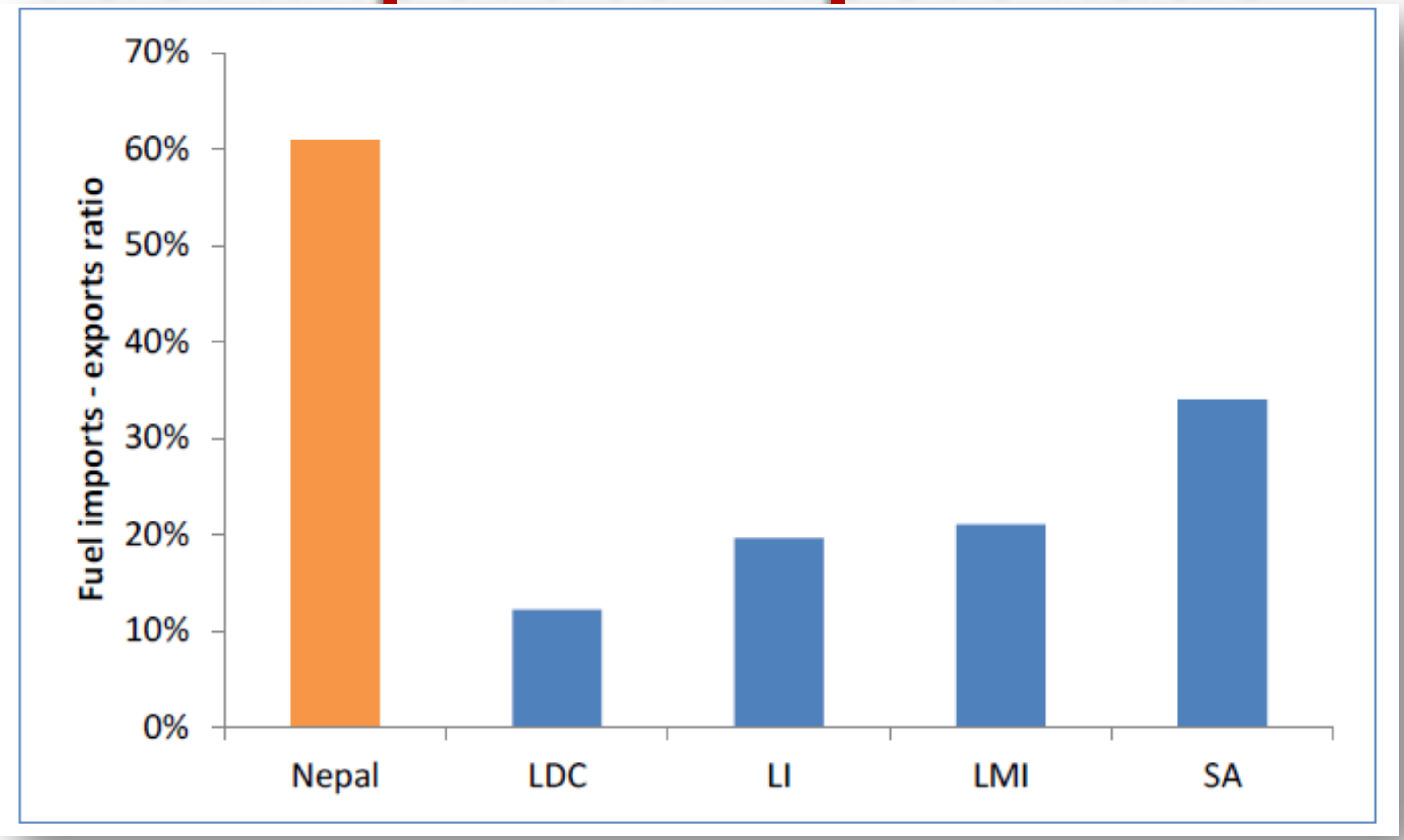
Renewable

- Hydropower
- Solar
- Wind
- Biomass, Biogas, Biofuel
- Geothermal

Petroleum Products Exploration

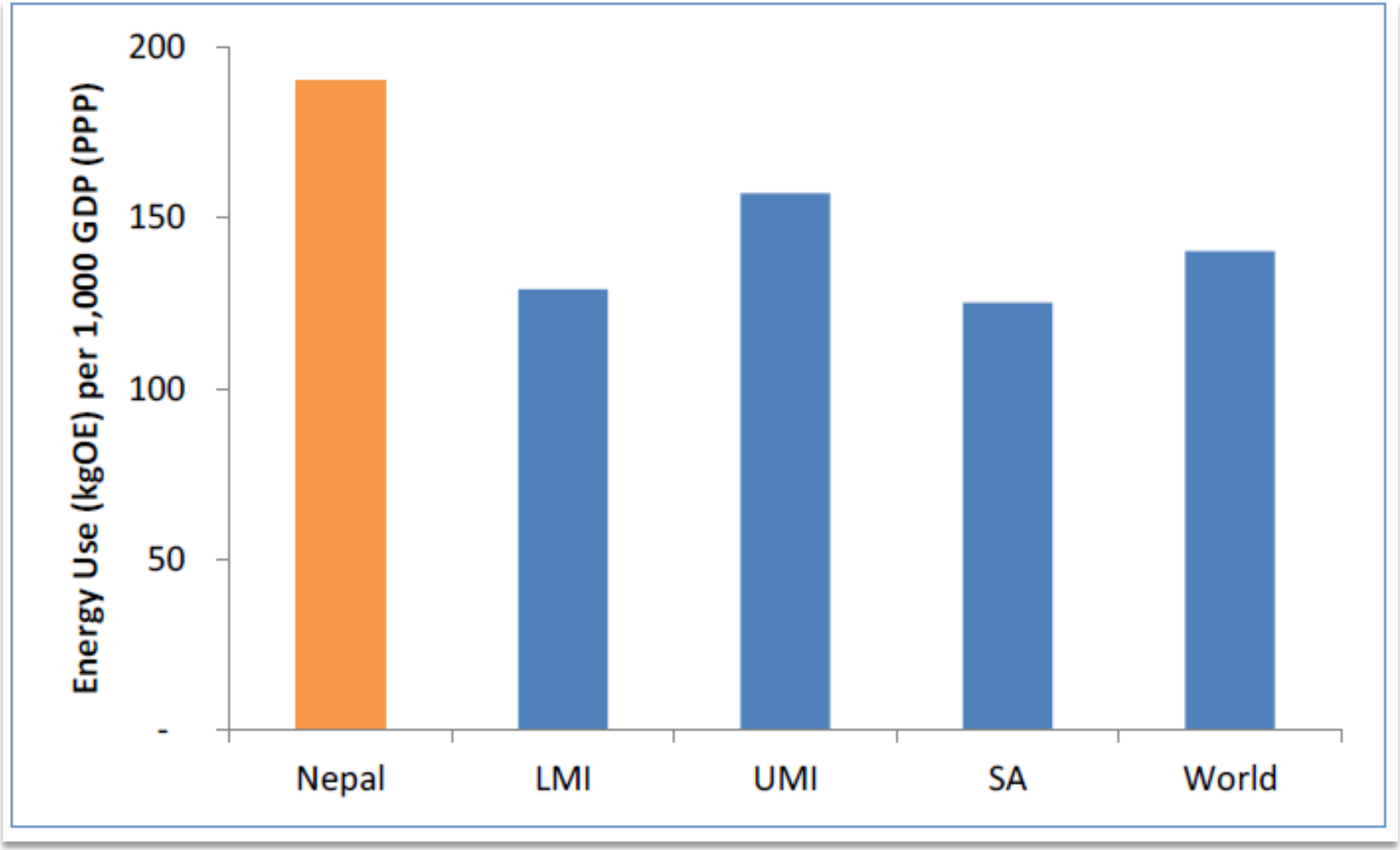
Figure 6: *Lease Block Outline*

Fuel Import to Export Ratio

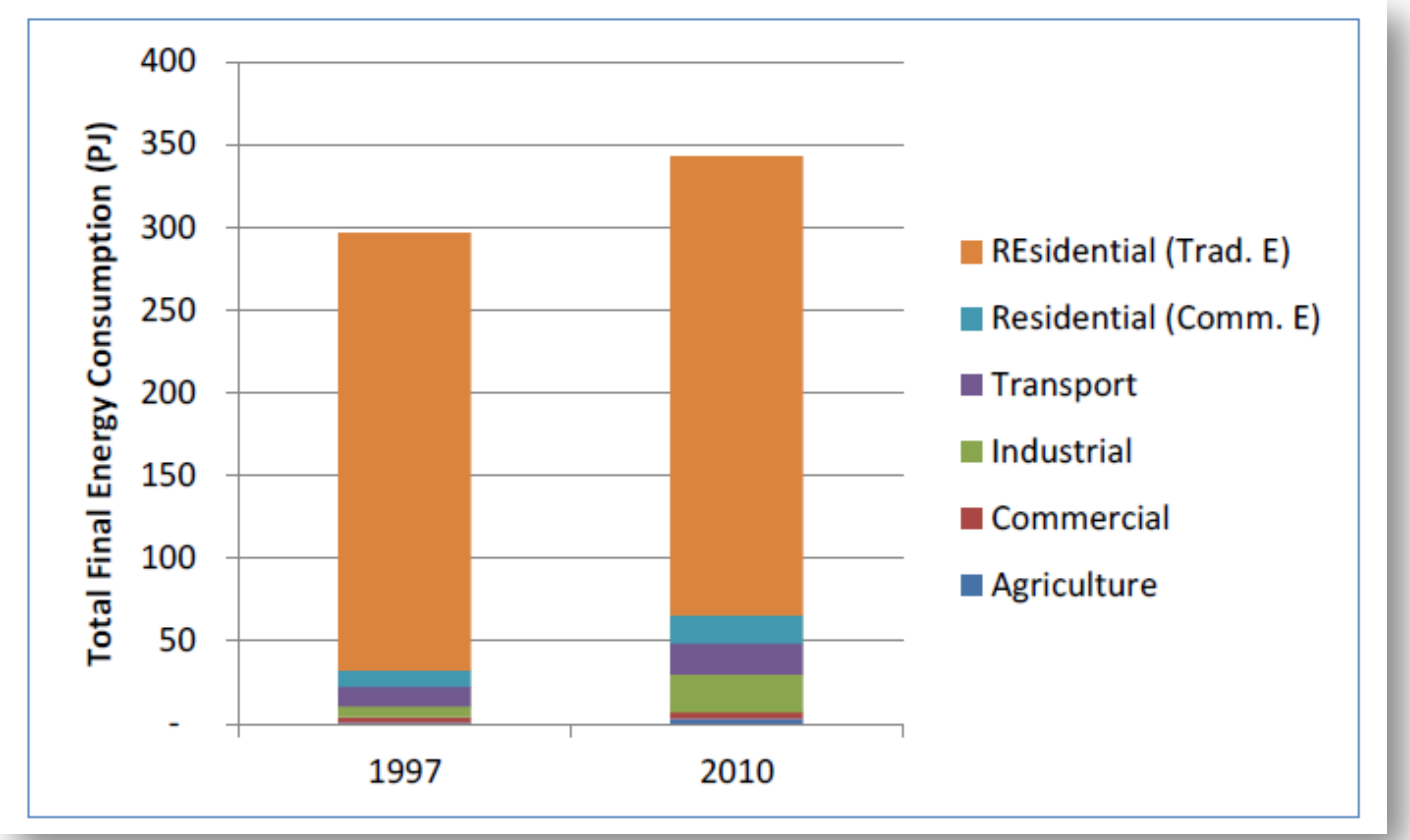


Note: World Development Indicators 2010, World Bank. LDC – Least developed countries, LI – low income countries, LMI – lower middle income countries, UMI – upper middle income countries, SA – South Asia. Numbers indicate average for countries within the blocks.

Embedded Energy Intensity in 2010



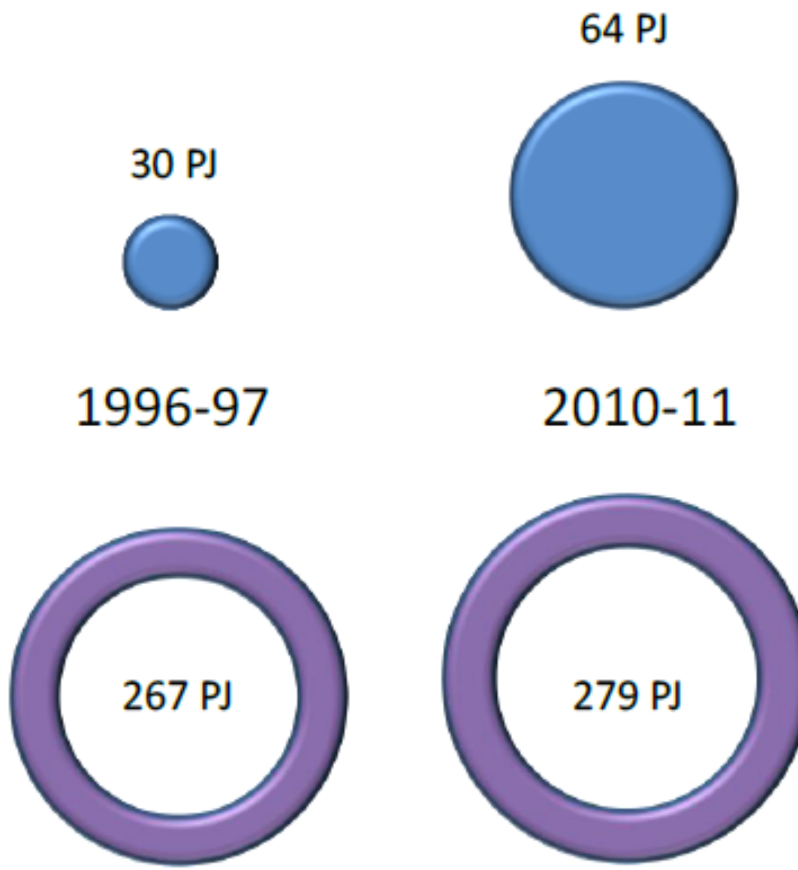
Energy Growth



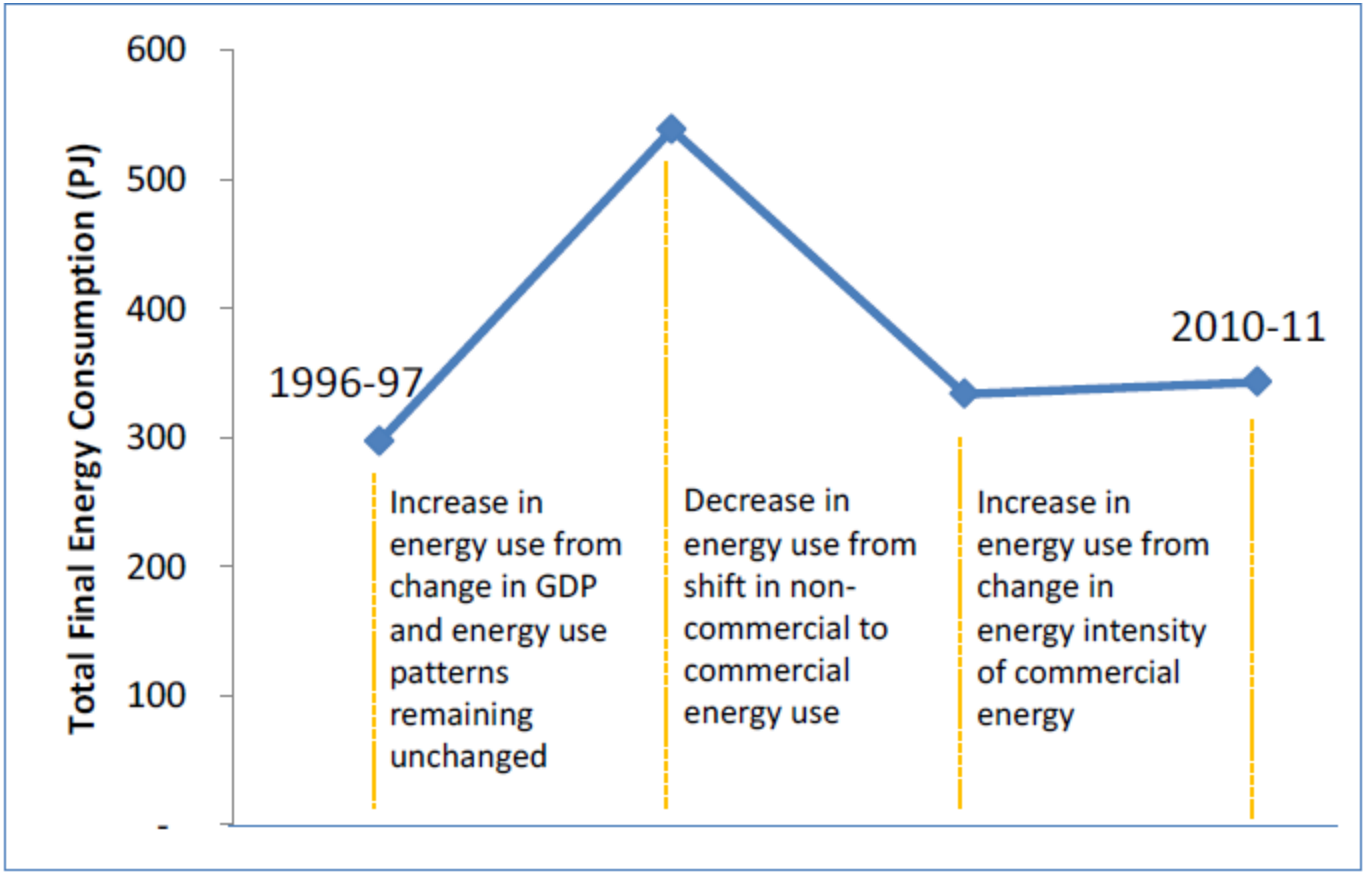
Growth Pattern of Total Energy Consumption

Between 1996-97 and 2010-11, commercial energy grew by ~5.5% annually on average

Between 1996-97 and 2010-11, non-commercial energy grew by ~0.3% annually on average



Decomposition of Energy Growth by Factors of Influence



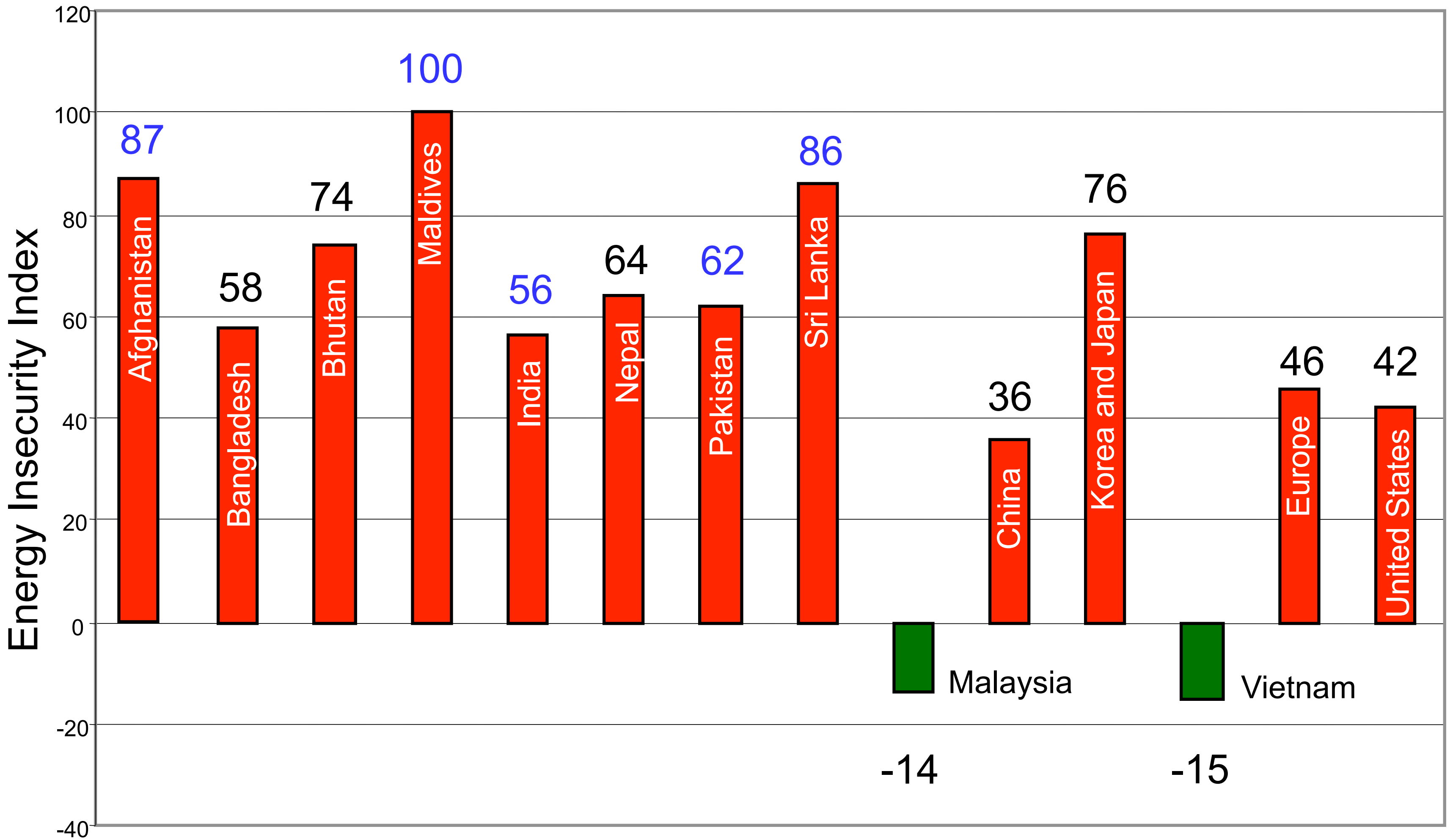
Energy Insecurity

Energy Insecurity Index is based on:

- ❑Share of net imports in total oil consumption *(40% weightage)*
- ❑Share of oil in total primary commercial energy consumption *(35% weightage)*
- ❑Share of the Middle East oil in total oil imports *(25% weightage)*

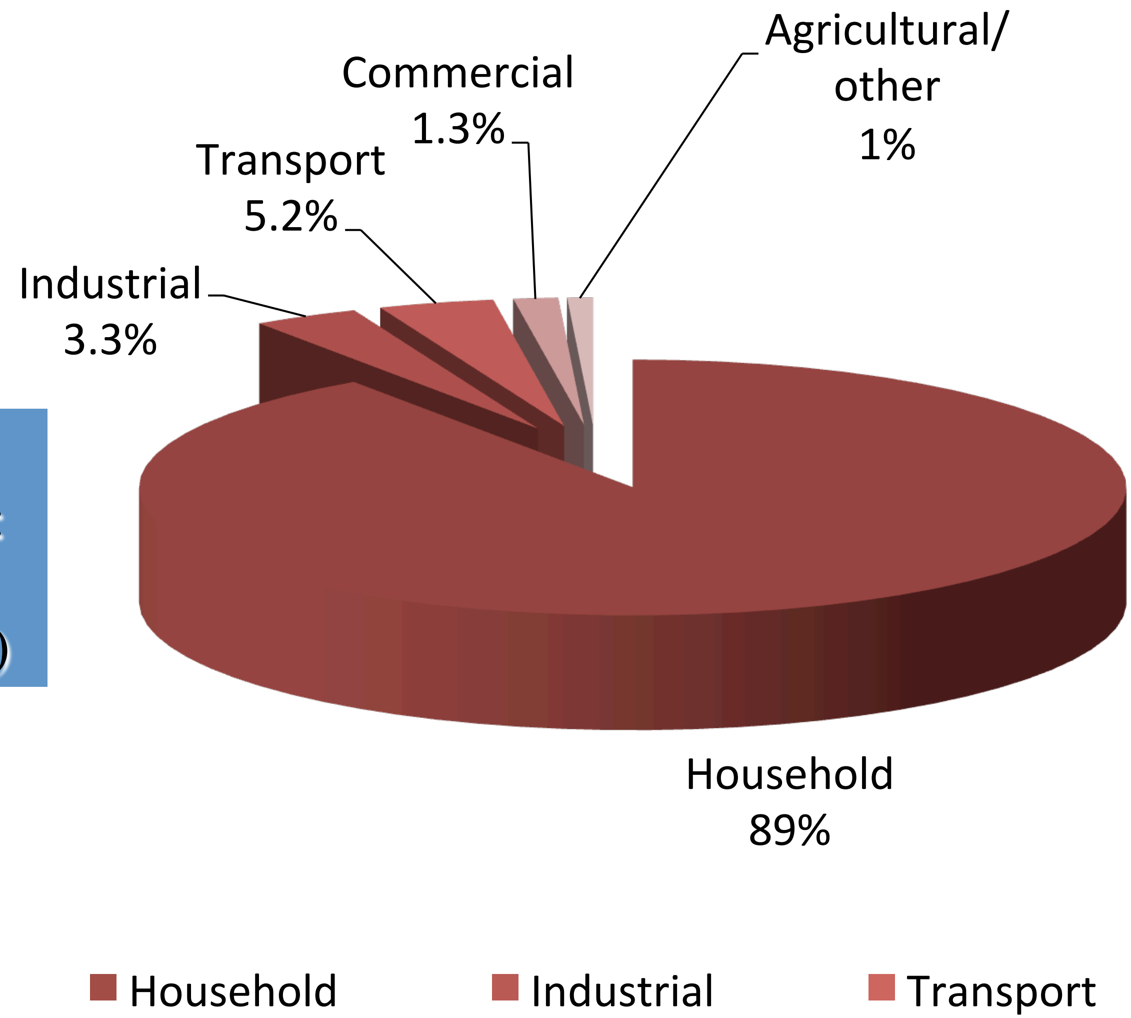
All South Asian countries suffer from energy insecurity and are projected to remain so in the foreseeable future

Energy Insecurity Index



Source: http://www.eastwestcenter.org/fileadmin/stored/pdfs/asiaenergyfuture10insecurityindex.pdf

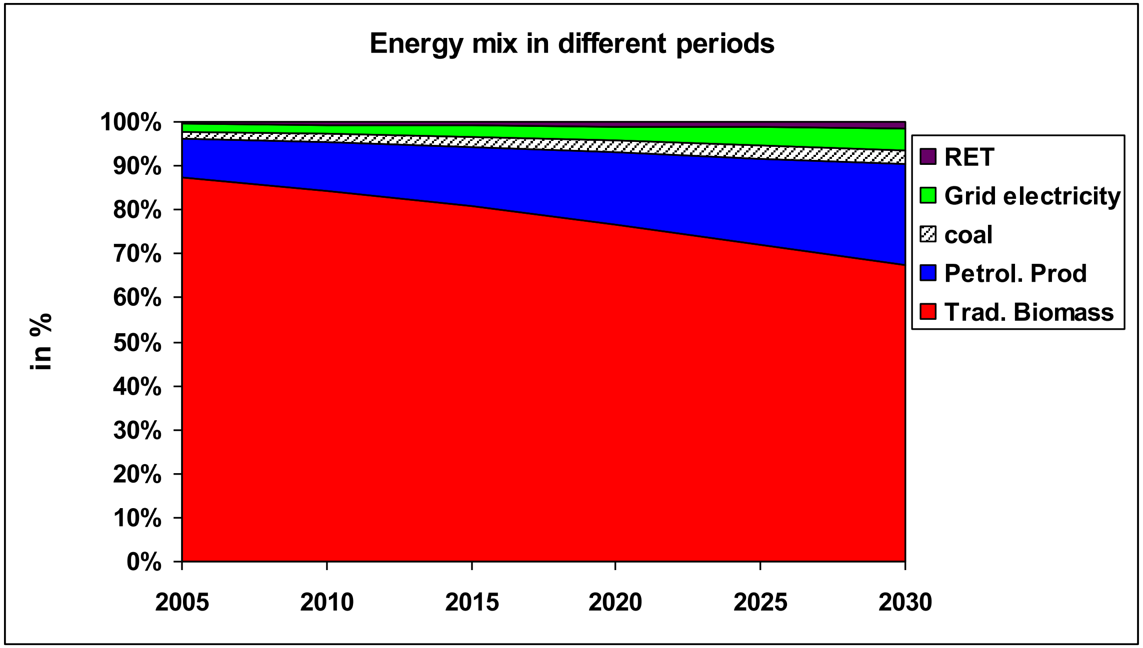
Nepal's End-use Consumption of Energy in Different Sectors in 2009



Total consumption: 400 million GJ (9.6 mtoe)

WECS, 2010

Nepal's Scenario
Fuel Mix at Reference case in 2030 % 5.5% GDP growth
(BAU case)



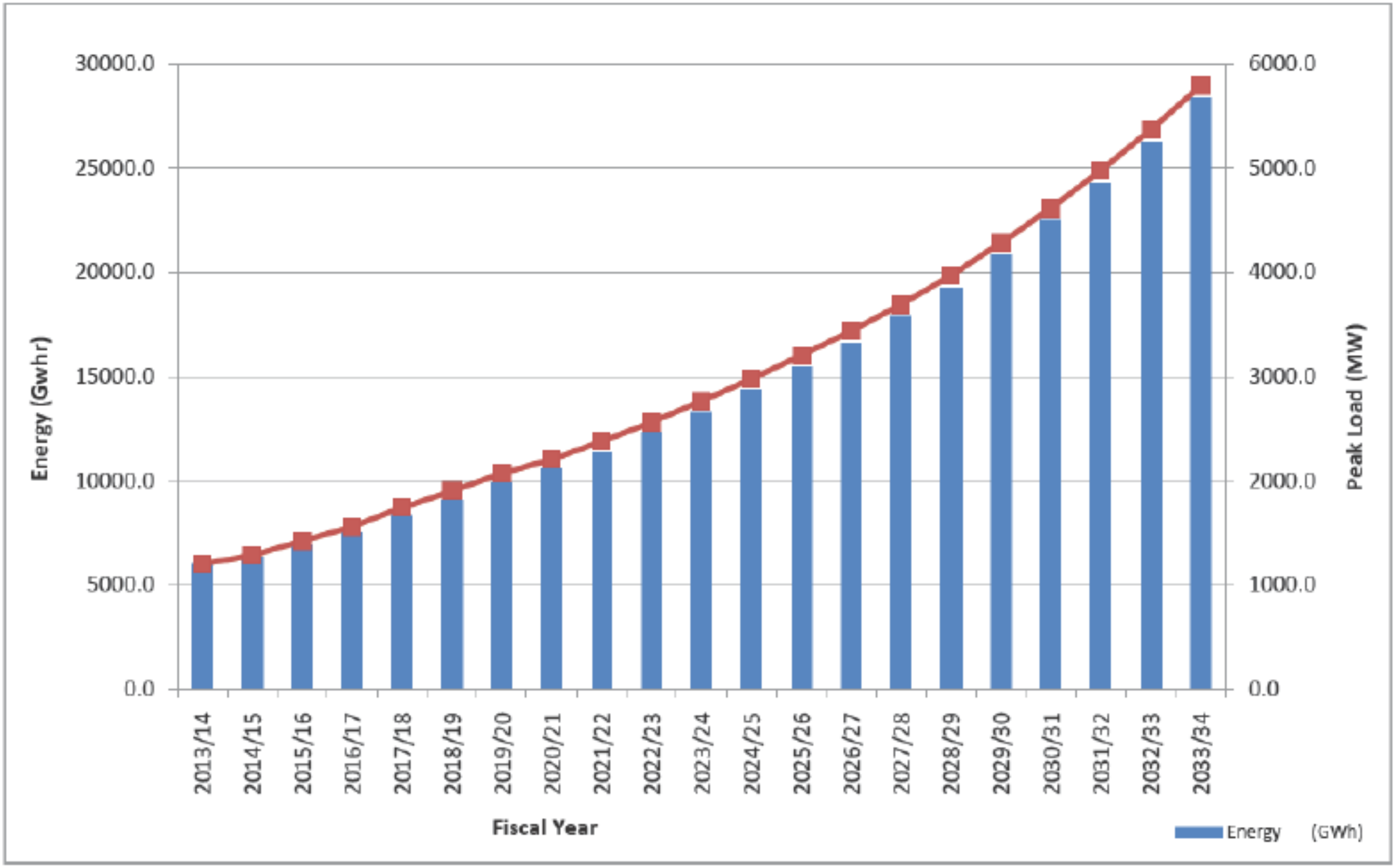
- Traditional: 64%
- Petroleum : 23%
- Grid – electricity:8%
- Coal: 3%
- Biogas+renewable:2%

The energy demand in 2030: 30.34 mtoe

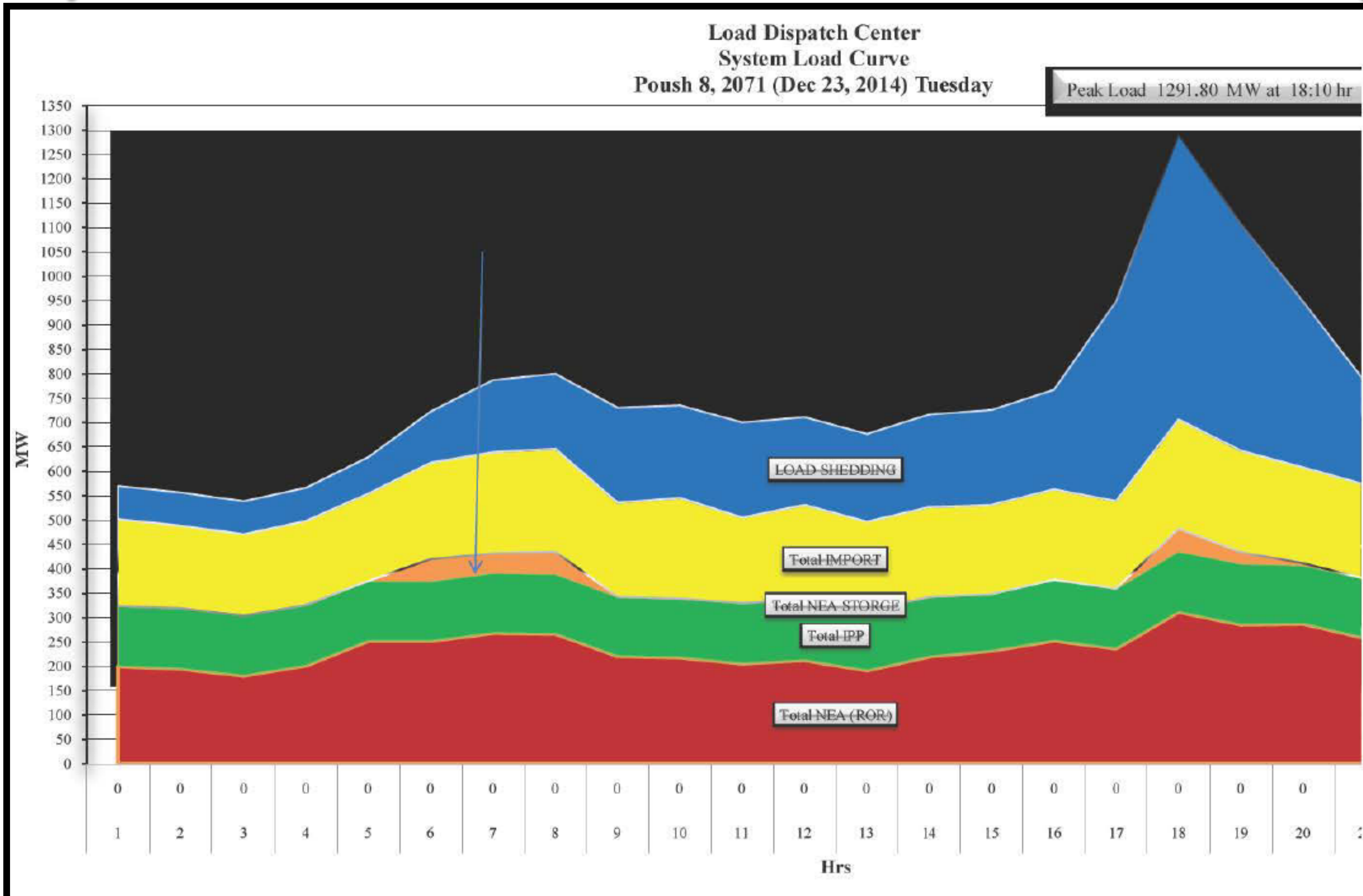

Nepal’s Power Sector
at a Glance
Nepal’s Water Resources

Status of Electricity Supply

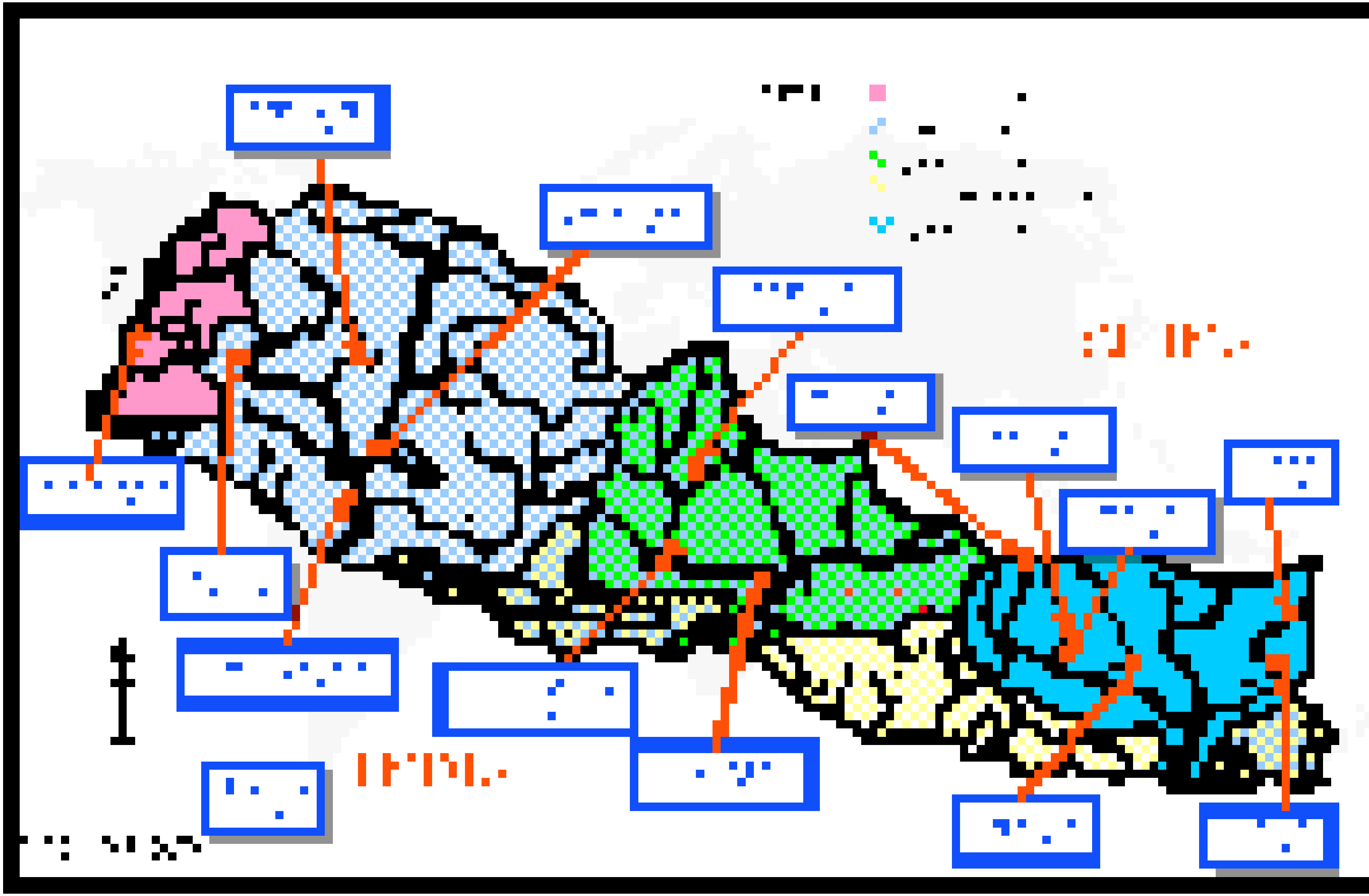
Load Forecast



System Load Curve of Peak of the Day



Major River Basins and Hydropower Projects in Nepal



- **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 theoretical and economical potential of hydro-power in Nepal are said to be about 83,000 MW and 43,000 MW respectively.**

So far only about 800 MW have been connected to peak load system, which constitute about 1.88% of total energy supply

Total Major Hydropower Plants of Nepal Electricity Authority (NEA)

Power Plants in operation	Installed Capacity (kW)
Total Small Hydro (NEA)-Isolated	4,536
Total Hydro (NEA)	477,930
Total Hydro (IPP)	255,647
Total Hydro (Nepal)	733,577
Total Thermal (NEA)	53,410
Total Solar (NEA)	100
Total Installed Capacity (NEA and IPP)	787,410
Total Installed Capacity (NEA and IPP)	782,451

Power Plants Under Construction	Capacity in kW
Upper Tamakoshi Hydropower Project	456,000
Tanahu Hydropower Project	140,000
Chameliya Hydro Electric Project	30, 000
Kulekhani III	14,000
Upper Trishuli 3A HEP	60,000
Rahughat HEP	32,000
Upper Sanjen	14,0001
Sanjen	42,000
Rasuwaghadi	111,000
Madhya Bhotekoshi	102,000
Upper Trishuli 3B	42,000
Total	1,044,100

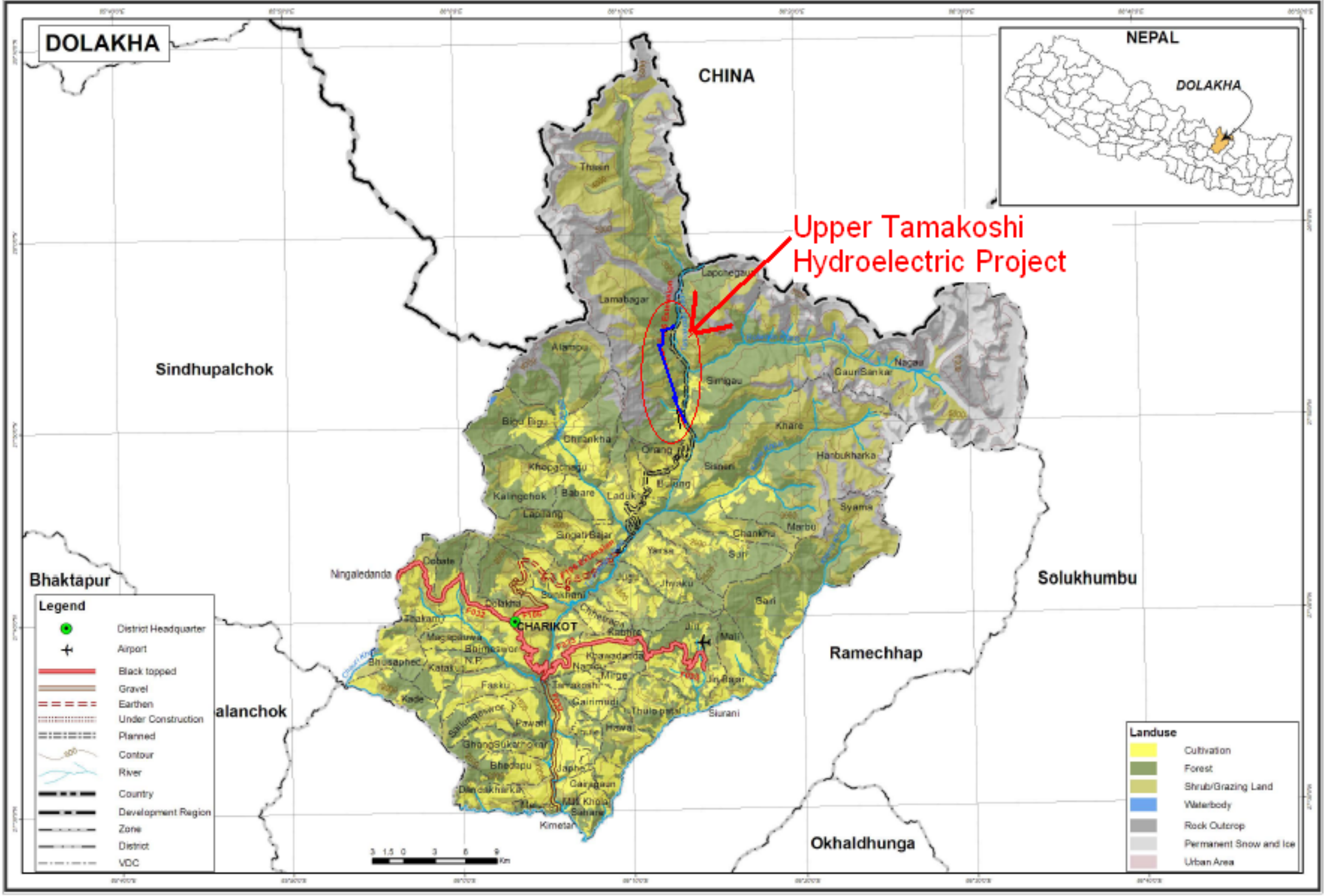
Planned and Proposed of HEP of NEA

Power Plants	Capacity in kW
Upper Arun Hydropower Project	335,000
Upper Modi A HEP	42,000
Upper Modi HEP	30, 000
Kulekhani III	18,000
Dudh Koshi Storage HEP	640,000
Tamor Storage HEP	530,000
Upper Ganga Storage HEP	300,0001
Tamakoshi V HEP	87,000
Upper Bheri HEP	85,000
Chainpur Seti HEP	140,000
Total	2177200

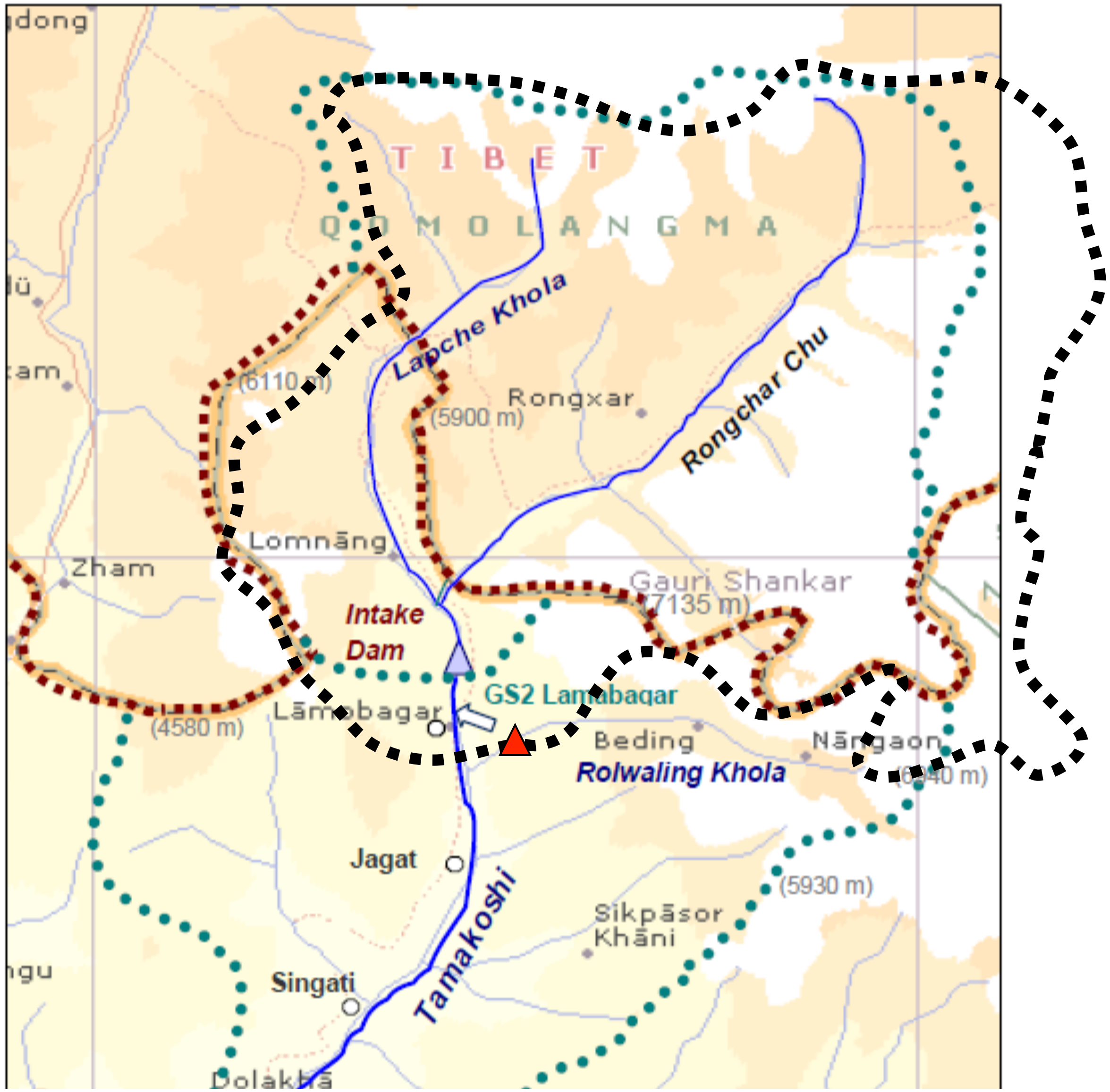
Source: www.nea.org.np/anual-report.html

A case study of :

UPPER TAMAKOSHI HYDROELECTRIC PROJECT

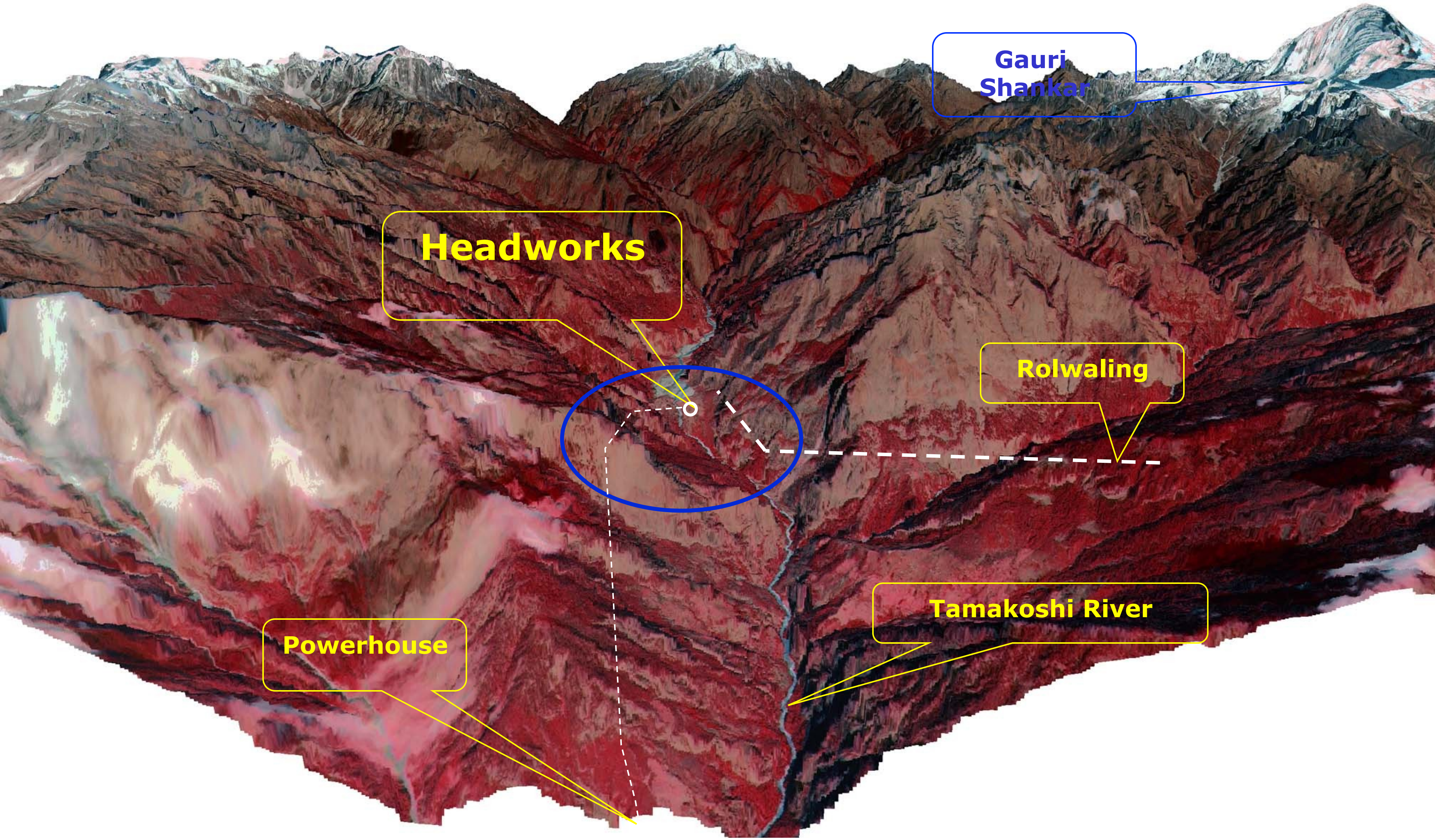


PROJECT LOCATION MAP



PROJECT LOCATION MAP

3D VIEW OF PROJECT AREA



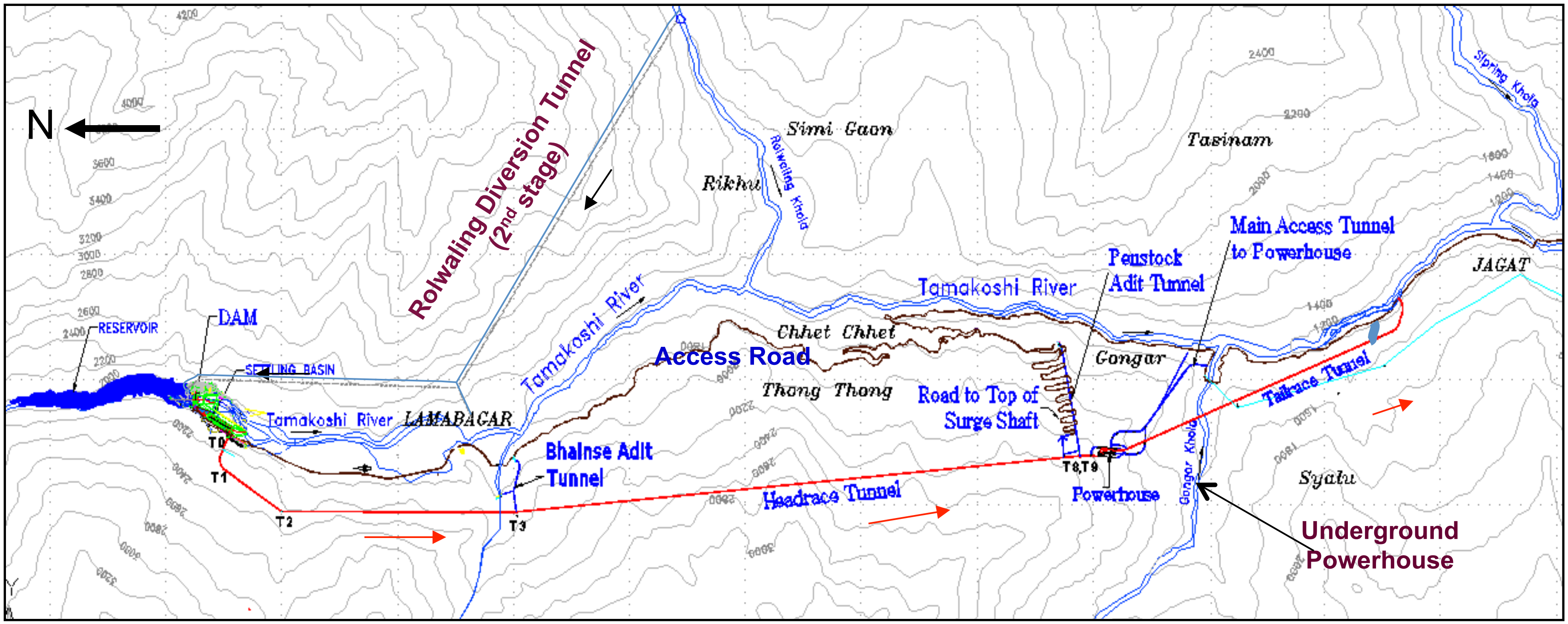
Salient Features

• Project Type	:	Daily Peaking Run-of-River
• Catchment Area	:	1745 Sq. km
• Installed Capacity	:	456 MW
• Annual Energy	:	2,281 GWh
• Design Discharge	:	66 m3/s
• Gross Head	:	822 m
• Headrace Tunnel	:	7.86 km
• Penstock	:	724 m
• Power House	:	Underground, 6 Units
• Tailrace Tunnel	:	2.98 km
• Transmission Line	:	220 kV double circuit, 47 km
• Project Cost	:	US$ 441 Mill. (Excl. IDC)
• Construction Period	:	5.5 years

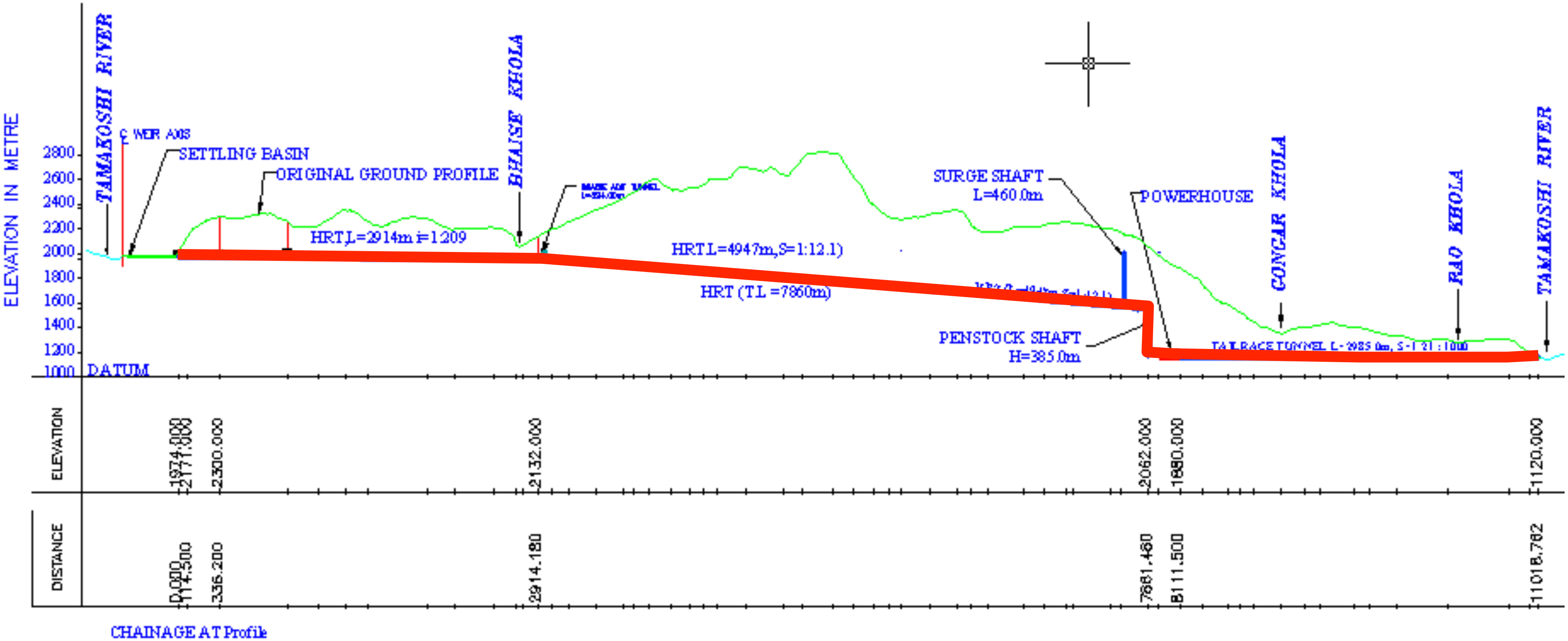
Special Features

- 300 m high natural dam
- Gross head of 820 m
- Good geology with presumably massive rock
- Comparatively very good minimum flow during dry season, low flood discharge during wet season
- Comparatively very low sediment influx
- Minimum environmental effect.

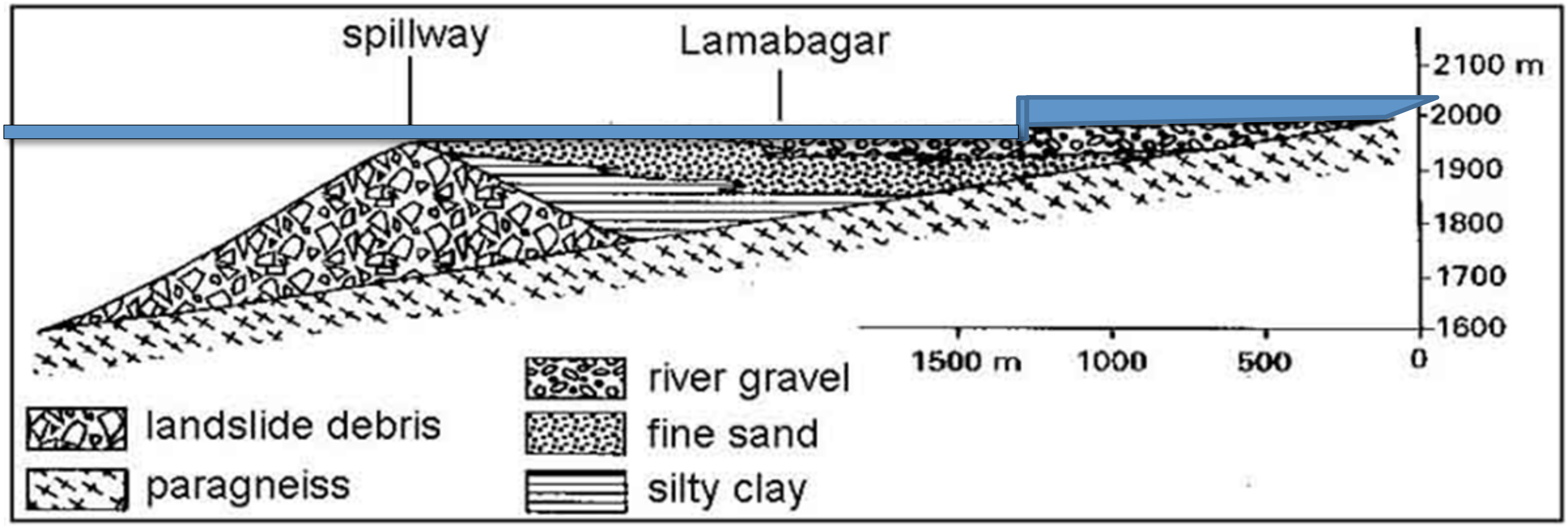
Project Plan



Project Profile

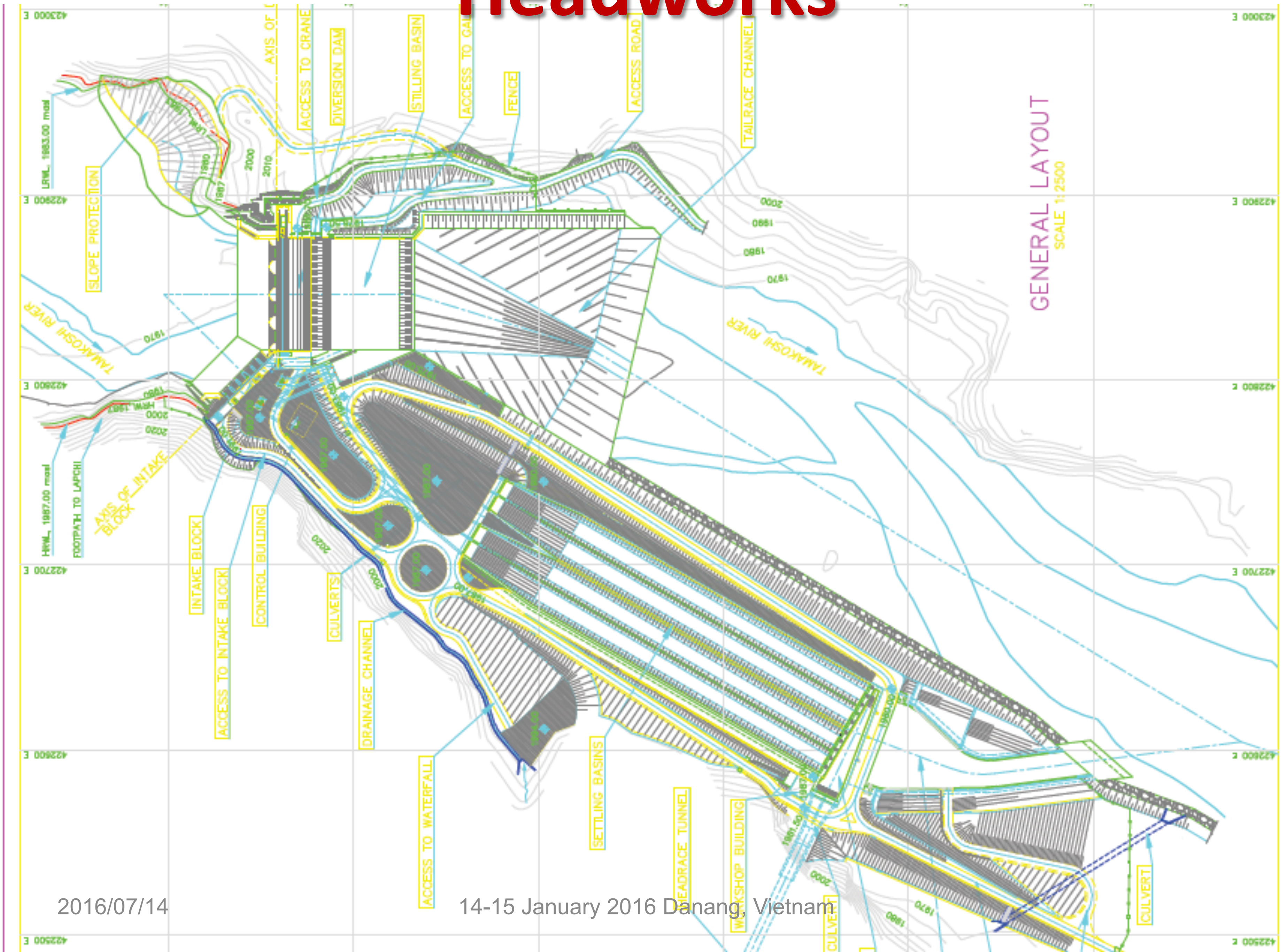


Natural Dam



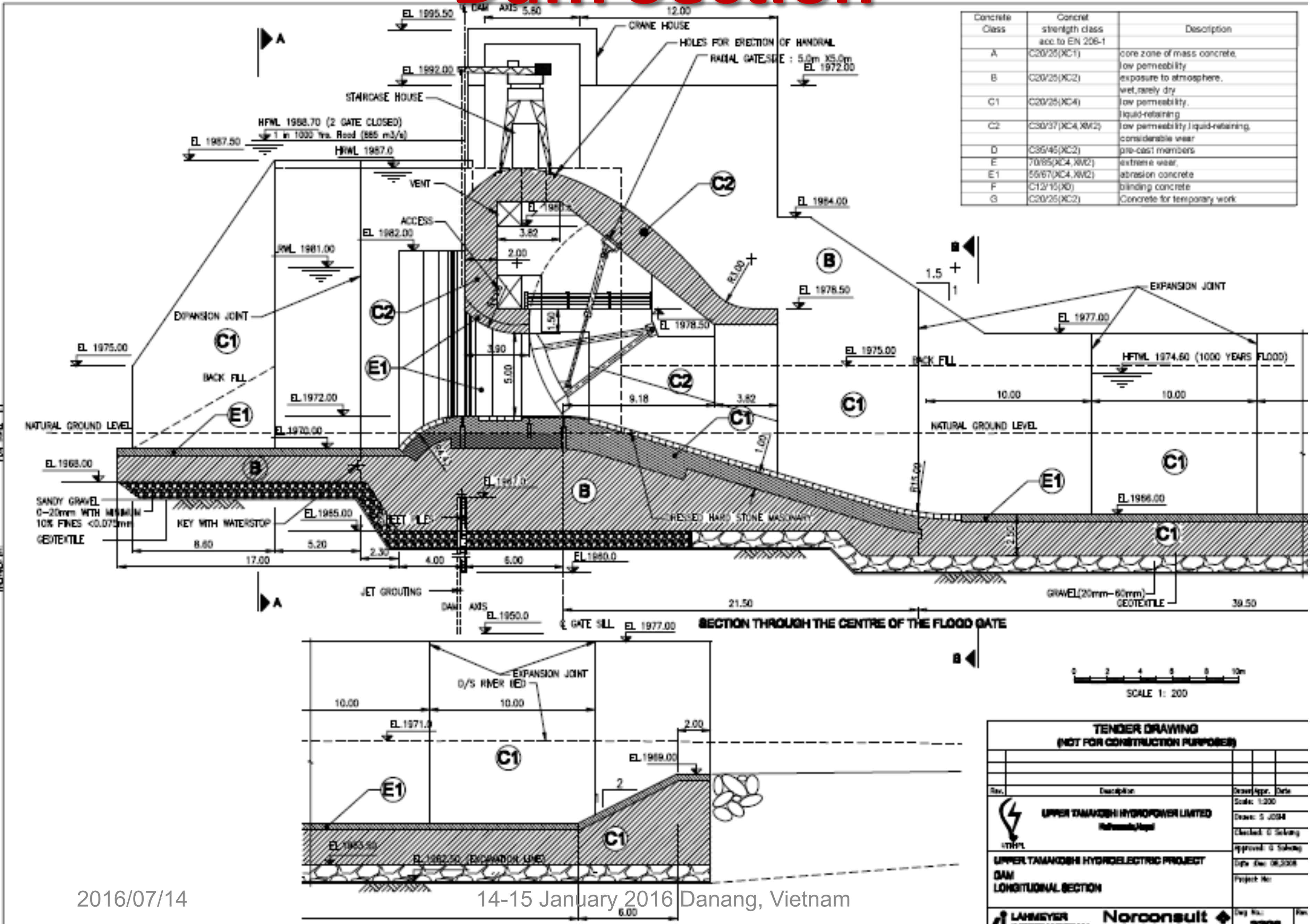
Idealized cross-section of the landslide dam and the sediment-filled basin. The sedimentary inventory is compiled by investigations on eroded landslide dams within similar environmental setting (Uhlir, 1999)

Headworks



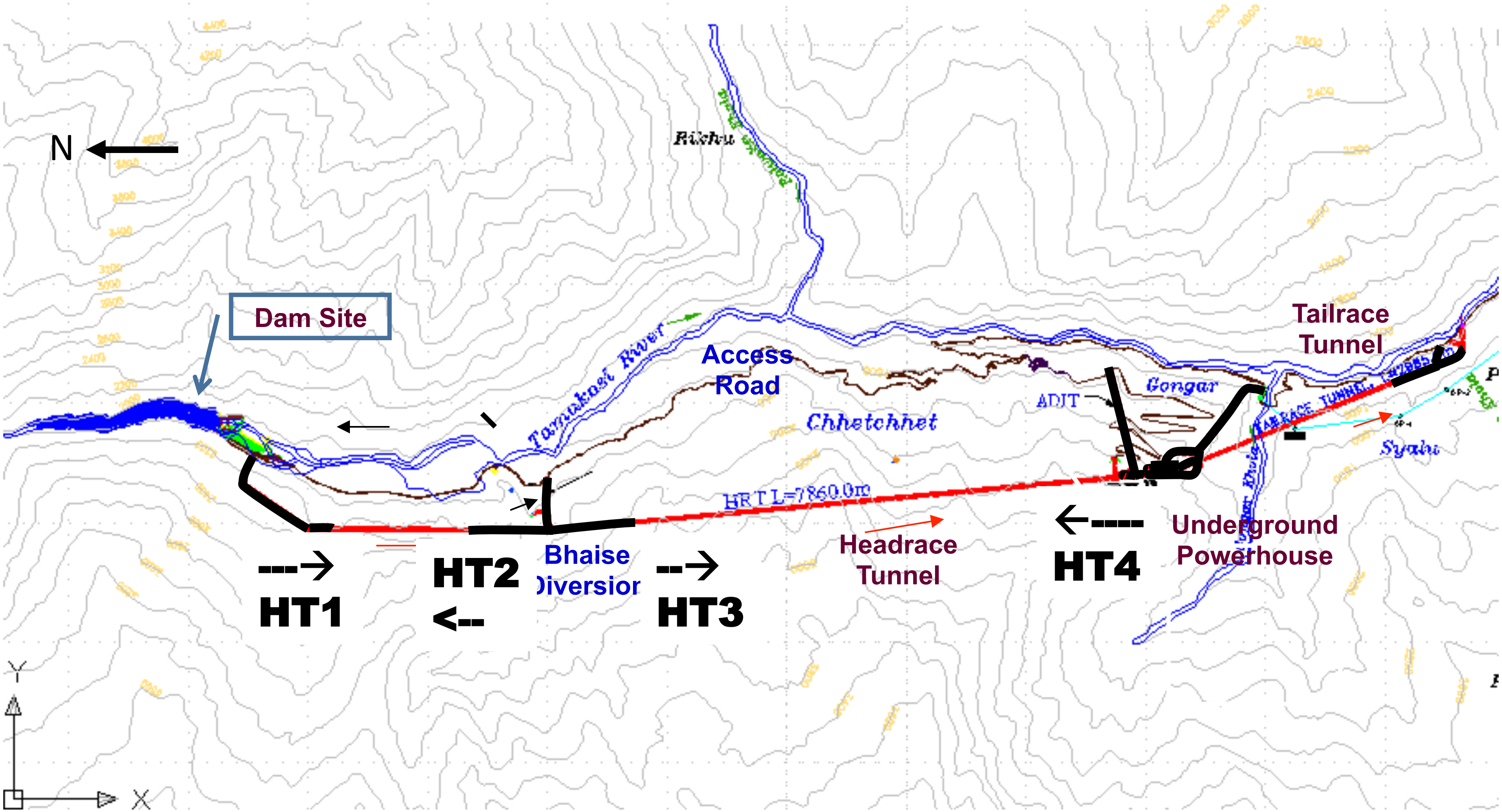
LRWL 1983.00 masl
SLOPE PROTECTION
AXIS OF
ACCESS TO CRANE
DIVERSION DAM
STILLING BASIN
ACCESS TO GA
FENCE
ACCESS ROAD
TAILRACE CHANNEL
GENERAL LAYOUT
SCALE 1:2500
TAMAKOSHI RIVER
TAMAKOSHI RIVER
HRWL 1987.00 masl
FOOTPATH TO LAPCHI
AXIS OF INTAKE BLOCK
INTAKE BLOCK
ACCESS TO INTAKE BLOCK
CONTROL BUILDING
CULVERTS
DRAINAGE CHANNEL
ACCESS TO WATERFALL
SETTLING BASINS
HEADRACE TUNNEL
WORKSHOP BUILDING
CULVERT
CULVERT

Dam Section



Concrete Class	Concret strength class acc.to EN 206-1	Description
A	C20/25(XC1)	core zone of mass concrete, low permeability
B	C20/25(XC2)	exposure to atmosphere, wet, rarely dry
C1	C20/25(XC4)	low permeability, liquid-retaining
C2	C30/37(XC4,XM2)	low permeability, liquid-retaining, considerable wear
D	C35/45(XC2)	pre-cast members
E	70/85(XC4,XM2)	extreme wear,
E1	55/67(XC4,XM2)	abrasion concrete
F	C12/15(X0)	blinding concrete
G	C20/25(XC2)	Concrete for temporary work

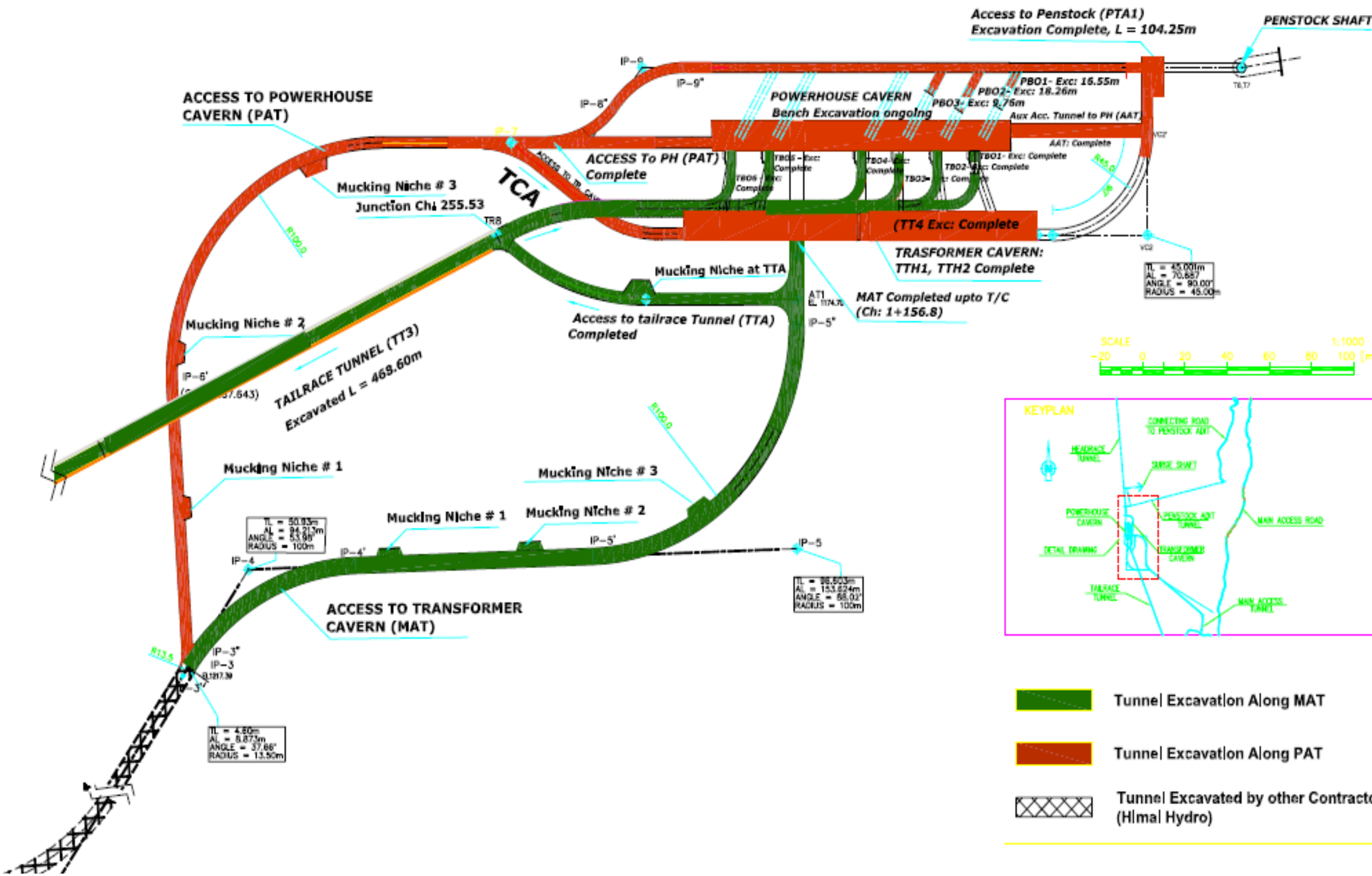
Progress of Tunnels

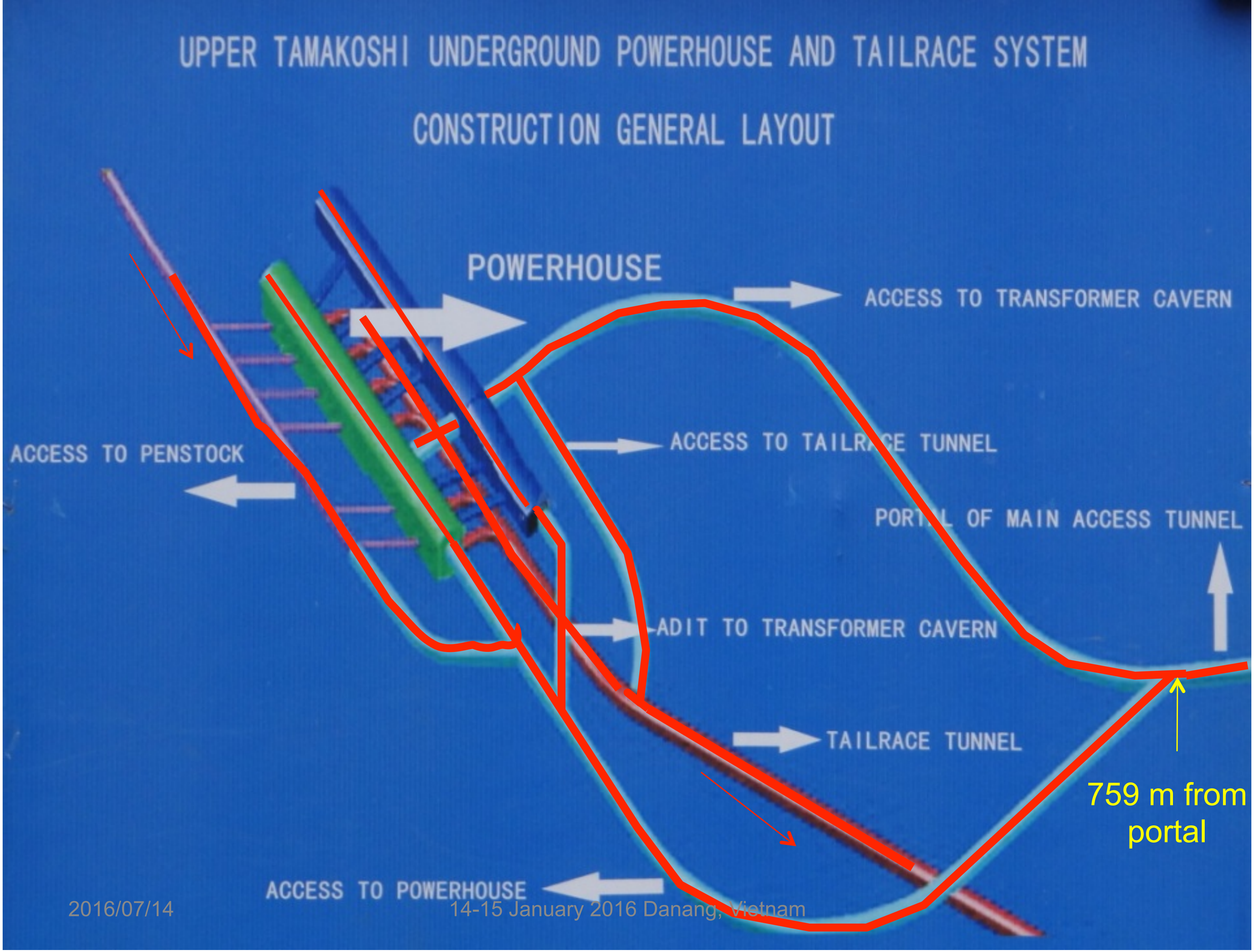


POWERHOUSE COMPLEX

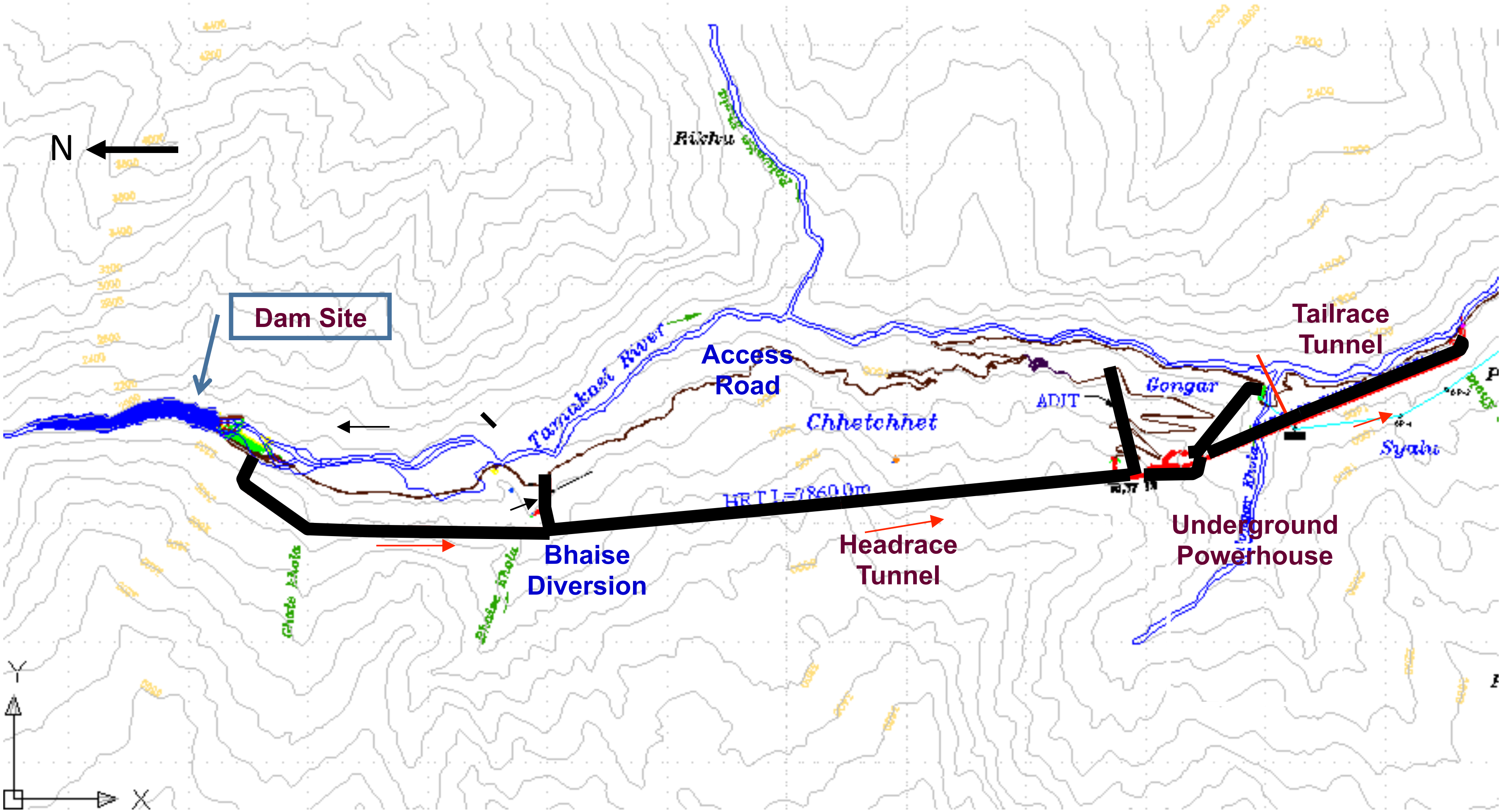
Tunnels In Powerhouse Complex

Status of Excavation

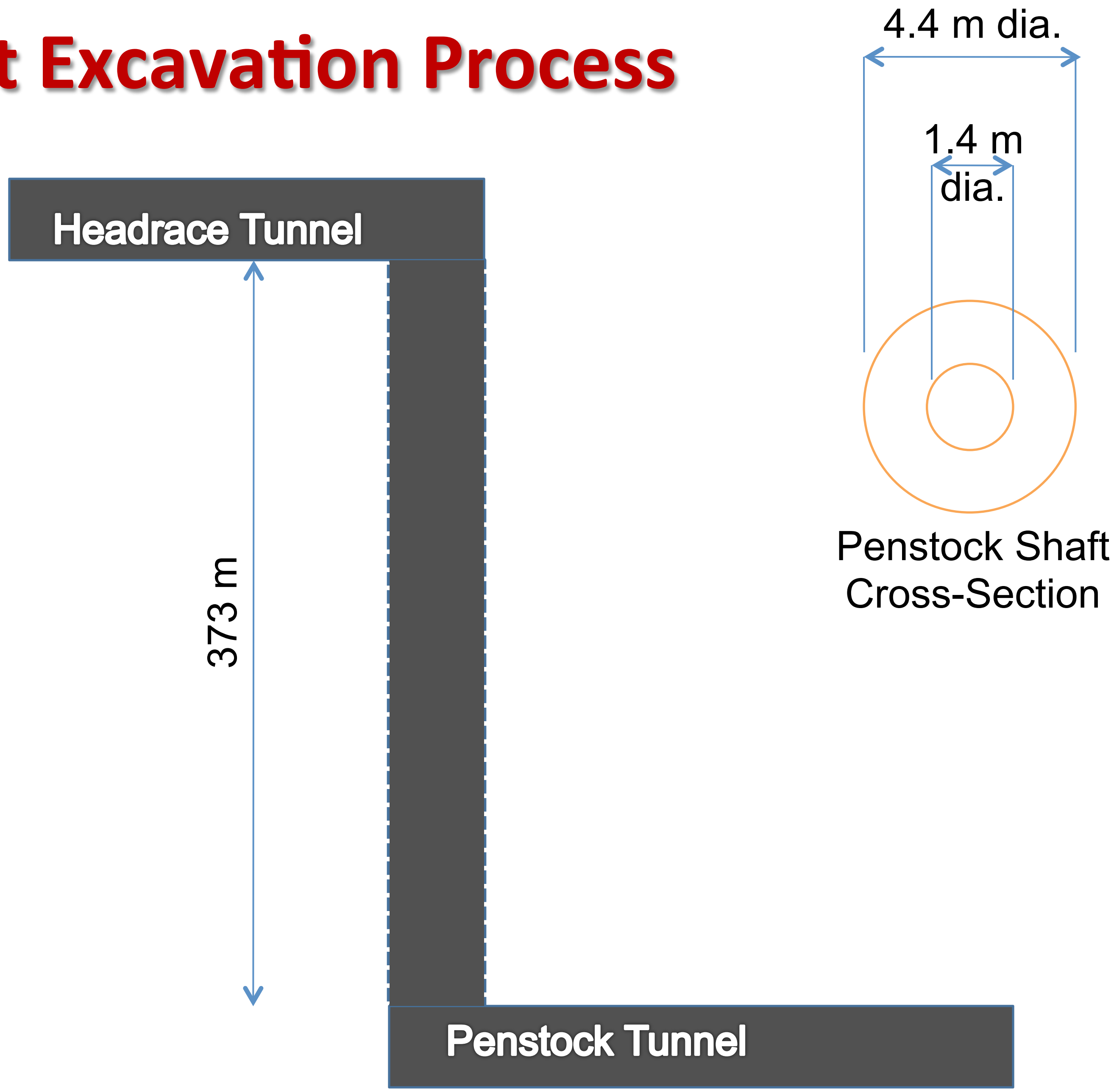



UPPER TAMAKOSHI UNDERGROUND POWERHOUSE AND TAILRACE SYSTEM
CONSTRUCTION GENERAL LAYOUT
POWERHOUSE
ACCESS TO TRANSFORMER CAVERN
ACCESS TO TAILRACE TUNNEL
ACCESS TO PENSTOCK
PORTAL OF MAIN ACCESS TUNNEL
ADIT TO TRANSFORMER CAVERN
TAILRACE TUNNEL
759 m from portal
ACCESS TO POWERHOUSE

Stages of Tunnel Excavation



Shaft Excavation Process






Cost Estimate

- The breakdown of the total project cost is as follows:

a) Main Works and Costs	=	NPR 28.15 Billion
b) Import duties and VAT	=	NPR 2.81 Billion
c) Contingencies	=	NPR 4.33 Billion
Total Project Cost	**=**	**NPR 35.29 Billion**
equivalent FC	**=**	**USD 441 Million**

(With Exchange Rate, 1USD = NPR 80.00)

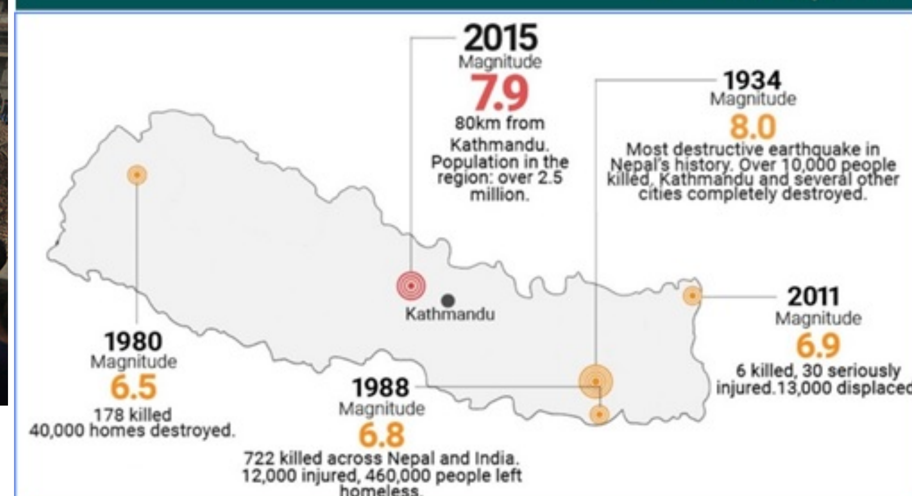
SUMMARY OF REVISED COST ESTIMATE

					As of	March-13
S.N.	**Items of Works**	**Approved Cost Estimate (Mar 2009)** in NRs.	**Estimated at Completion as of Mar 2013 (Note#1)** in NRs.	**Difference** in NRs.	**Exchange Rate** for Base Year	**Remarks**
A	Lot 1 : Main Civil Works	18,123,769,848	17,091,082,285	(1,032,687,563)	NRs.75.19/USD	47.0%
B	Lot 2 : Hydromechanical Works	1,801,308,864	1,814,303,739	12,994,875	NRs.99.98/Euro	5.0%
C	Lot 3 : Electromechanical Works	9,282,616,000	8,933,120,448	(349,495,552)	NRs.71.25/USD	24.6%
D	Lot 4 : Transmission Line and Substation Works	1,785,081,344	2,442,376,050	657,294,706	NRs.88.69/USD	6.7%
E	**Total A+B+C+D**	**30,992,776,056**	**30,280,882,522**	**(711,893,534)**		**83.3%**
F	Access Road, Preliminaries and Other Works	1,762,702,759	1,956,018,974	193,316,215	-	5.4%
G	Consultancy Services	1,596,510,080	2,064,471,744	467,961,664	NRs.75.45/USD	5.7%
H	Owner's Administration Cost	533,690,480	1,621,026,676	1,087,336,196	NRs.75.00/USD	4.5%
I	Land Acquisition, Environmental Mitigation & Management	408,480,000	408,480,000	-	-	1.1%
	Total F+G+H+I	**35,294,159,375**	**36,330,879,916**	**1,036,720,540**		**100.0%**

	BREAKDOWN			**Difference**
	Major Costs	28,151,460,015	29,125,474,876	974,014,862
	VAT	1,991,035,621	2,077,818,790	86,783,169
	Contingencies (Price & Physical)	4,334,588,139	4,214,510,649	(120,077,490)
	Provision for Customs Duty	817,075,600	913,075,600	96,000,000
	Total Cost (With VAT)	**35,294,159,375**	**36,330,879,916**	**1,036,720,540**

Note#1 : Amount is inclusive of Provision for Exchange Rate Risks, amounting to NRs.2,571,631,067/-
with average exchange rate of NRs. 84.23/- per 1 USD

Nepal's Earthquake 2015



Earthquake damages over dozen hydropower projects

The devastating earthquake of April 25 and series of aftershocks that followed the main shake have damaged around 14 hydropower plants across the country, resulting to loss of 150 MW of electricity from country's power grid.

Damage: NEA owned Power Plants

Project	Capacity	Status
Trishuli	24 MW	Cracks in the crest in the balancing pond, staff quarter damaged, not in operation, but can be restored within short period
Devighat	14 MW	A cascade project of Trishuli, cannot operate until Trishuli resumes
Sunkoshi	10.05 MW	Several leakage in a stretch of 200 meter canal
Kulekhani	60 MW	Cracks in the crest of the dams, but in operation
Chilime	22 MW	Damage in operation line
Upper Trishuli 3A (under construction)	60 MW	Severe damage in the construction works after landslide from both sides not only killed four employees but also buried heavy equipment; damage in the audit tunnels and suspension bridge

Damage: Private owned Power Plants

Project	Capacity	Status
Upper Bhotekoshi	45 MW	Penstockk burst due to rock slide, powerhouse submurged due to penstock burst; rock slide continues after earthquake; no excess to power plant
Sunkoshi Khola	2.5 MW	Powerhouse wall has fallen inside power-house room, landslide at penstock alignment and landslide at headwork areas, no access to plant
Indrawati -III	7.5 MW	Significant damage, but in operation
Chaku Khola	3 MW	Not in operation
Baramchi Khola	4.2 MW	Penstock pipe burst
Middle Chaku	1.8 MW	Not in operation
Spring Khola	9.65 MW	Extension joint burst
Ankhu Khola-1	8.4 MW	Sub-station power house fully damage by landslides
Mailung Khola	5 MW	Significant damage in headworks
Bhairab Kunda	3 MW	Leakage in tunnel, penstock burst

Source http://www.nepalenergyforum.com/earthquake-damages-over-dozen-hydropower-projects/

Climate Vulnerability Issue:

SUSTAINABILITY OF HYDROPOWER DEVELOPMENT

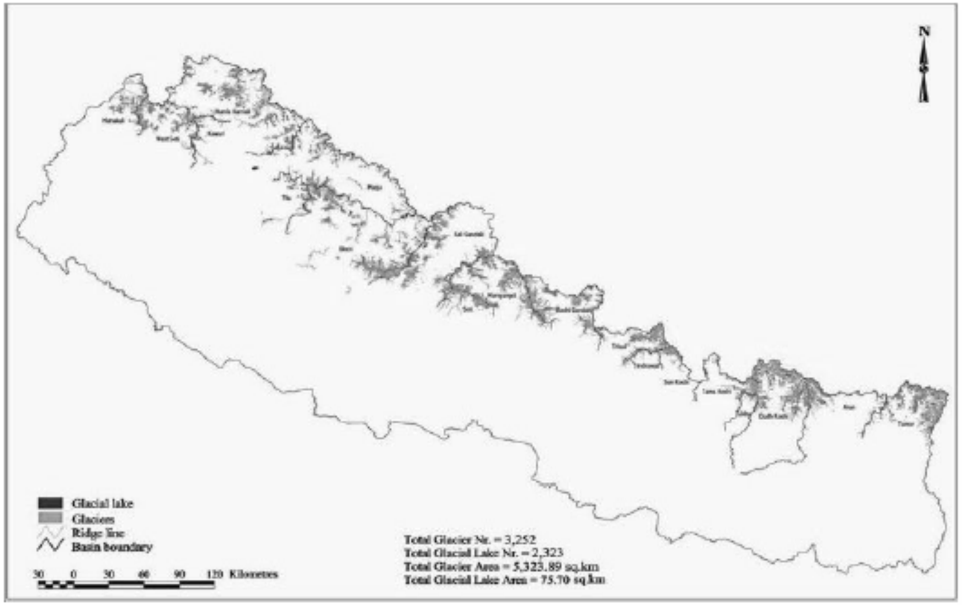
Climate-change, Glacial lakes and Hydropower

- The most critical impacts of climate change in Nepal are related to its water resources and hydropower generation, stemming from glacier retreat, expansion of glacial lakes, and changes in seasonality and intensity of precipitation.

Impact

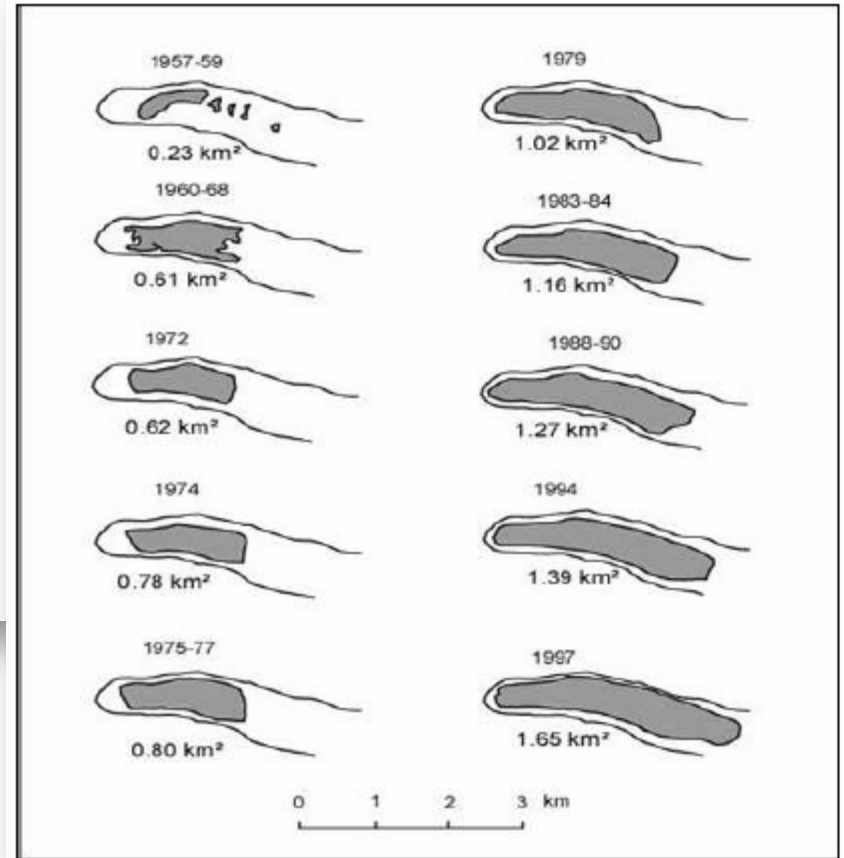
- Increased risk of Glacial Lake Outburst Flooding (GLOF)
- Increased run-off variability (as a result of glacier retreat, more intense precipitation during monsoon, and potentially decreased rainfall in the dry season)
- Increased sediment loading (and landslides) as a result of GLOFs, as well as intense rainfall events
- Increased evaporation losses from reservoirs as a result of rising temperatures

Glacial Lake Outburst Flooding (GLOFs)



Glacial lakes and potential GLOF sites in Nepal

Source: ICIMOD



Increase in area of the Tsho Rolpa Glacial Lake 1957-1997

Source: Department of Hydrology and Meteorology, GoN

- GLOF risks should not pose excessive barriers to hydropower developments
- Planners and investors should undertake risk assessment s and work to understand how GLOFs and climate change can be managed.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THANK YOU

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