PV-Based Dual-Axis Self-Tracker in Remote Area Power Supply System (RAPS) for Rapid Rural Electrification in Nepal

Experience of Kathmandu University (KU)

NEA's 50 kW PV-power plant in Simikot, Humla, Source: Zahnd et al, 2006

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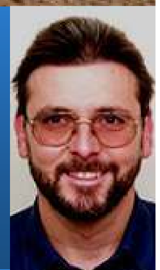
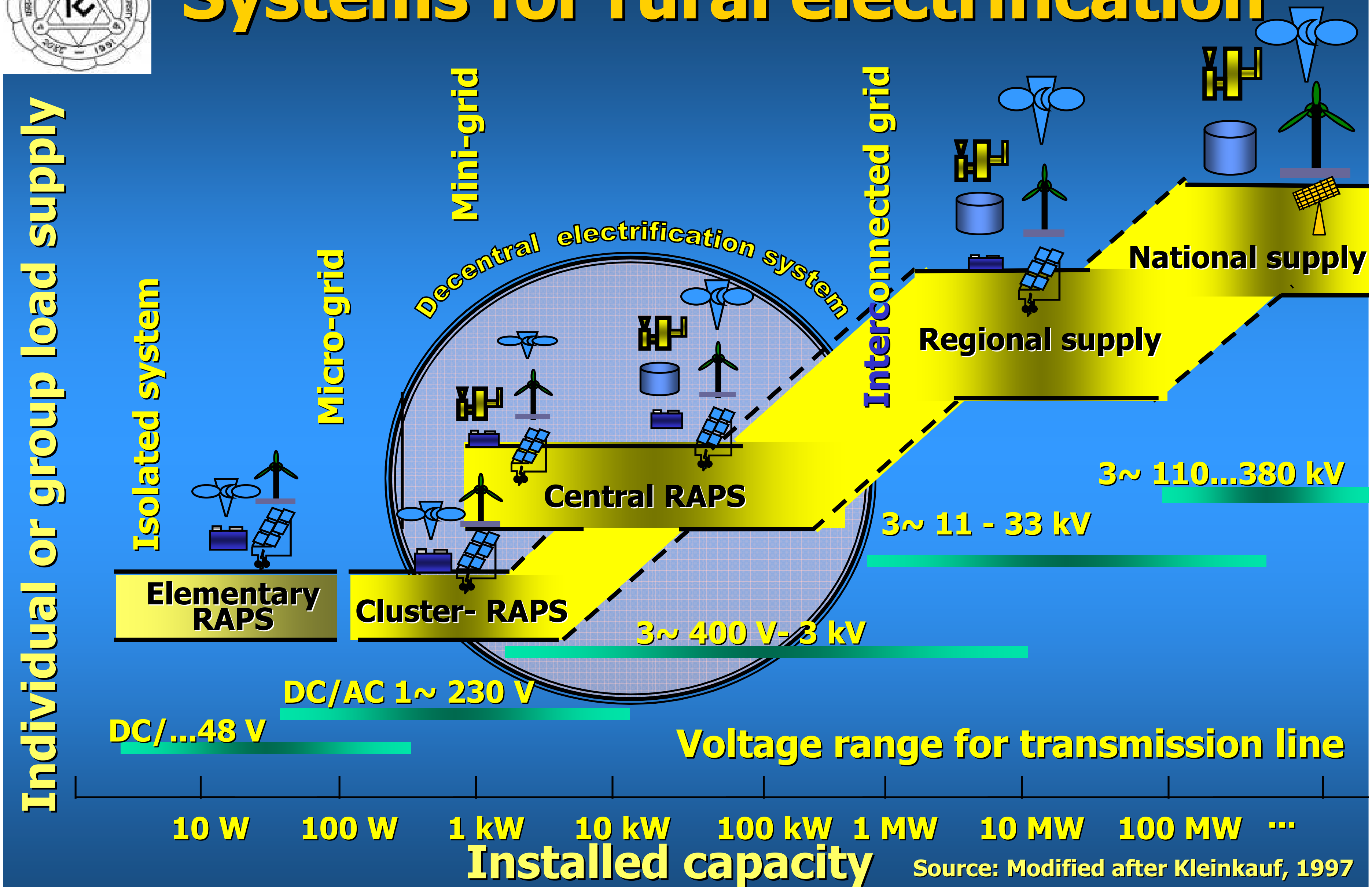
Interest: R&D in renewable energy technologies

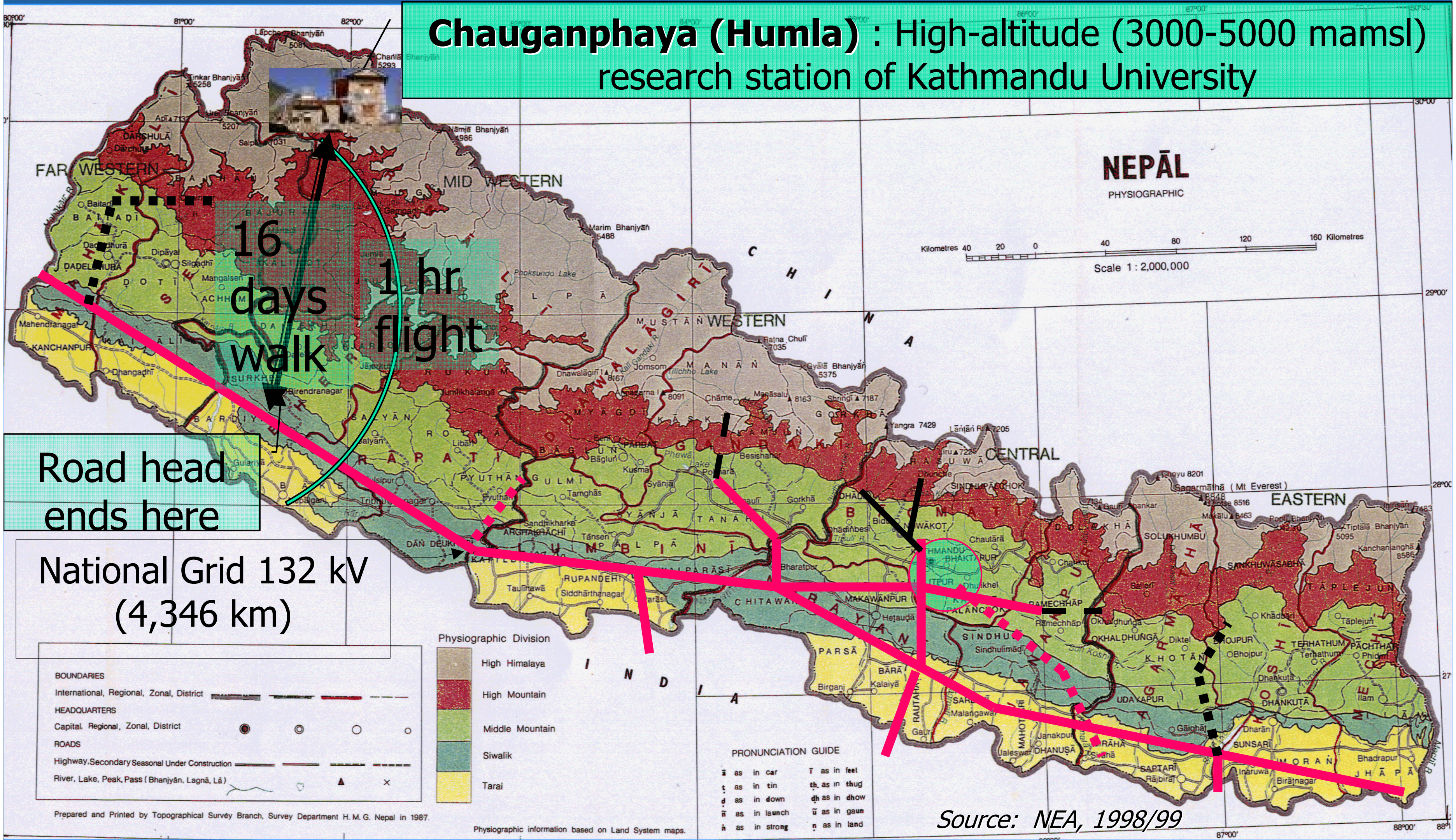


Systems for rural electrification



Source: Modified after Kleinkauf, 1997

Prospect for rural electrification



Need assessment: Holistic community development (HCD)

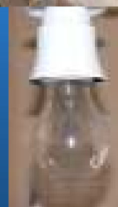
Region	OECD Countries	Developing countries	Nepal
Per capita electricity consumtion in kWh	2500 in 2000	900 (Hunwick, 2002)	69 (Kathmandu Post, 2005)

- RET: a part of basic HCD:

- No light & open fire
- Fire hazard
- Indoor pllution
- Respiratory diseases
- Blindness
- Heart attacks
- No drinking water
- No sanitation

- Choices:

60 W



LE: <1000 hrs.

11 W

LE: <12,000 hrs

1 W

LE: <50,000 hrs

Source: Photo and information from Zahnd, 2002

Problems and prospects for RAPS

Harsh Condition

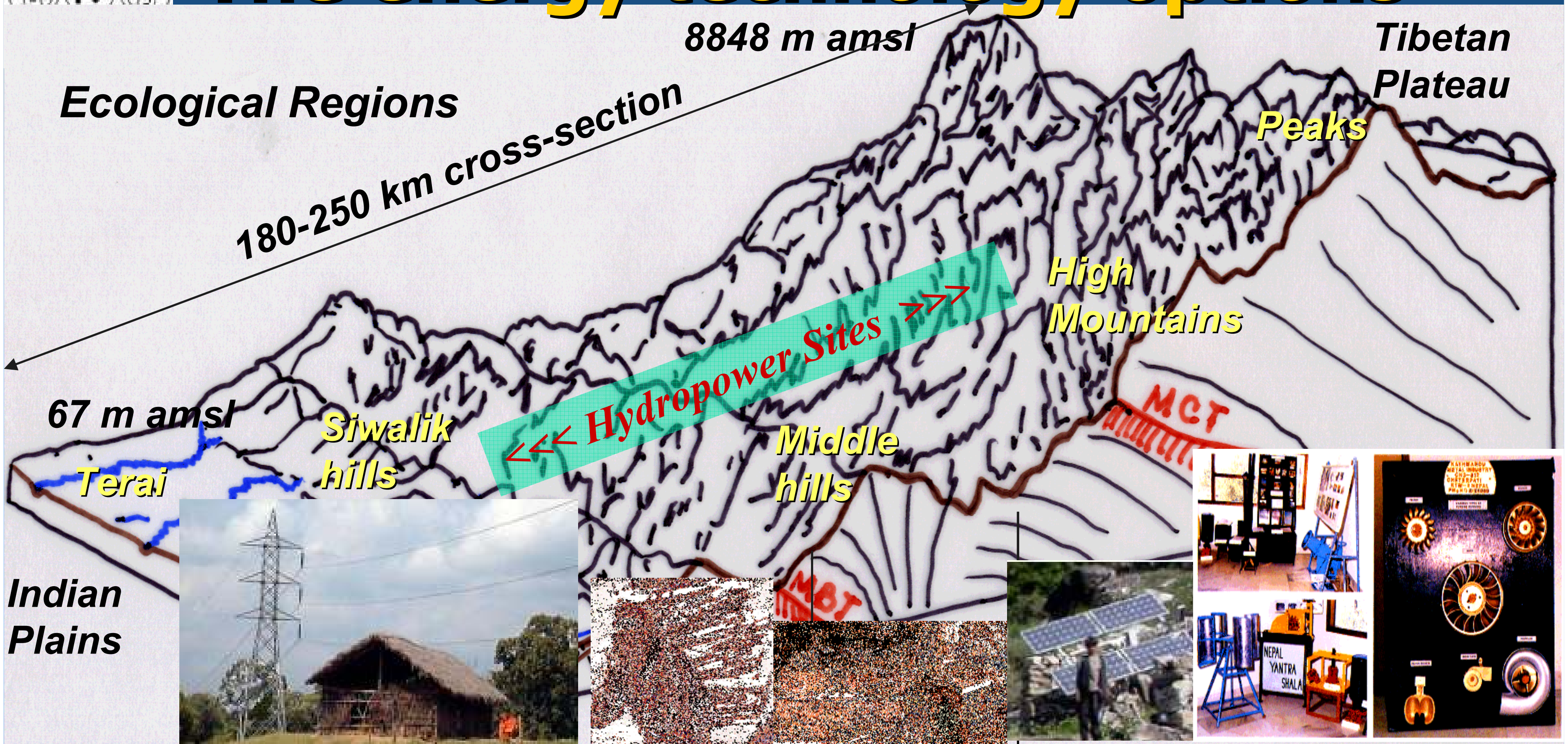
Sparse Settlements

- Sustainable and appropriate
- A part of HCD
- Protect environment
- Matches with load
- Resources (fund, fuels)
- Local entrepreneurship

Tourism

Deforestation

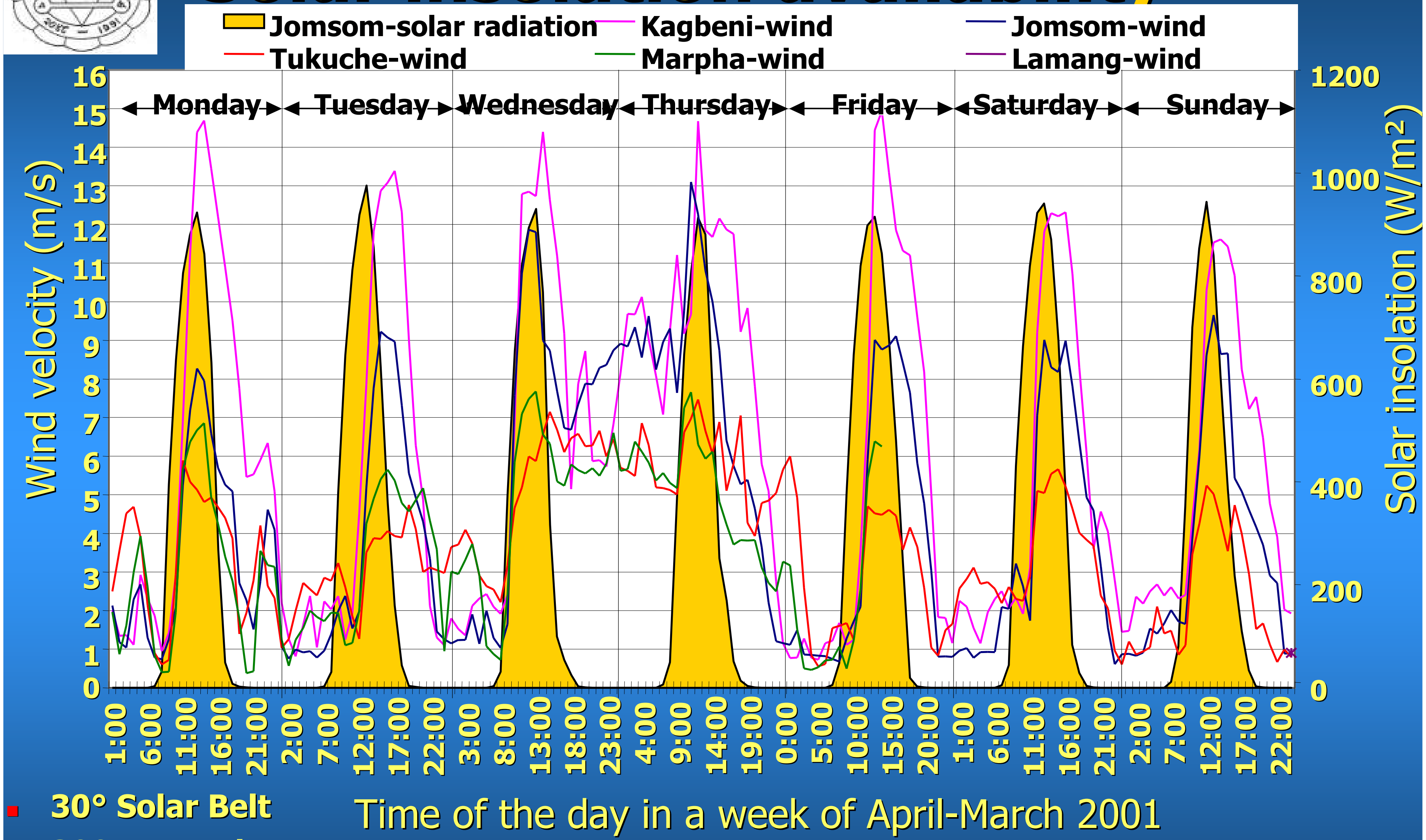
The energy technology options



Population	Dense	Grouped	Scattered
Key features	Easy access Import accessible	Less easy access Import more expensive	Difficult or no access Import impossible unless very portable or via air lift
Energy options	Diesel/Biogas/Grid	Diesel/Bio-mass/Hydro	Micro-hydro/Solar/Wind

Source: modified from Aitken et al, 1991, Zahnd, 2006

Solar insolation availability



- **30° Solar Belt**
- **300 sunny days**
- **4.8-6 kWh/m² /day Irradiation**

[Egger et al, 2002; Maskey, 2004]

Government policy for RET in Nepal

- Government (AEPC) aims at: providing 1 RET/household for 58% of rural population by 2020 with the following visions:
  - Decentralized energy system through active participation
  - Development through market mechanisms

Solar home system	Cost US$	Subsidy US$	Remarks
• One Solar module 10-40 W • Battery deep cycle 40-75 AH • Three 10-20 Watt fluorescent lamps	300 - 400	Max. 110	• Additional 50% and 2.5% subsidy per SHS for remote households • 75% for public institutions • reduced by 10% per annum
Solar Entrepreneurs within 10 years of introducing SHS in Nepal			>15 (mostly in Kathmandu)

[Source: Zahnd et al, 2006; CADEC, 2004, CES 2000]

Installed capacity of Renewable Energy Technology in Nepal

Source of electricity from small renewable energy technologies		Number of installation	Total capacity (kW)
Solar home systems in 73 districts		61,891	2,024.574
Micro-hydro electrification schemes	804 turbine mills (7,106.9 kW)	1,371	7,472
	872 improved watermills (pani-*ghatta*),		
Biogas plants		111,395	766,147 m³
Wind power plants (demonstration)		6	1.2

[Source: Zahnd et al, 2006; CADEC, 2004]

Electrified households in Nepal

Source of electricity	Percentage of households*
NEA and other isolated systems (domestic consumers)	29.83
Solar home system	1.02
Micro-hydro schemes	1.86
Non-domestic category of consumers of NEA and other systems	0.97
Not known (non-reported solar home systems, illegal connection)	5.71
Total reported by the 2001 Census	39.39

* Total households are 4,174,374. The average household size is ~5.4 [CADEC, 2004 and CBS, 2000]

Kathmandu University

Quality education for leadership

Estd. in 1991 as University

Rector's Office

Master plan

- **Staff excld. affiliated colleges**
  - Regular faculty(Professors 96) — 192
  - Regular visiting scholars — 19
  - Occasional visiting scholrs — 28
  - Non-teaching staffs — 125
- **Assets as of 2004**
  - Land in Ha — 45
  - Buildings in m² — 20,600
- **Enrolment as of 2004**
  - Students in six schools (Natural science, Management, Engineering, Medical science, Arts and Education) — 2,212
  - Affiliated colleges in six different programs — 3,519
- **Academic degree as of 2003**
  - Graduate diploma, Bachelor — 1,844
  - Masters and PhD — 393

Student research project for SHS

- **Two PV-panels mounted on 30 degree**
- **Connected differentially with motor**
- **Components:**
  - **Primary sensors**
  - **Secondary sensor**
  - **Frame and shaft**
  - **Gear and pinion**
  - **Gear head motor**
  - **Screw jack**
  - **Underground cable**
  - **Battery bank**
  - **White-light emitting diode (WLED)**

Info and Photo: Pandey et al, 2006

Student research project…

Feature:

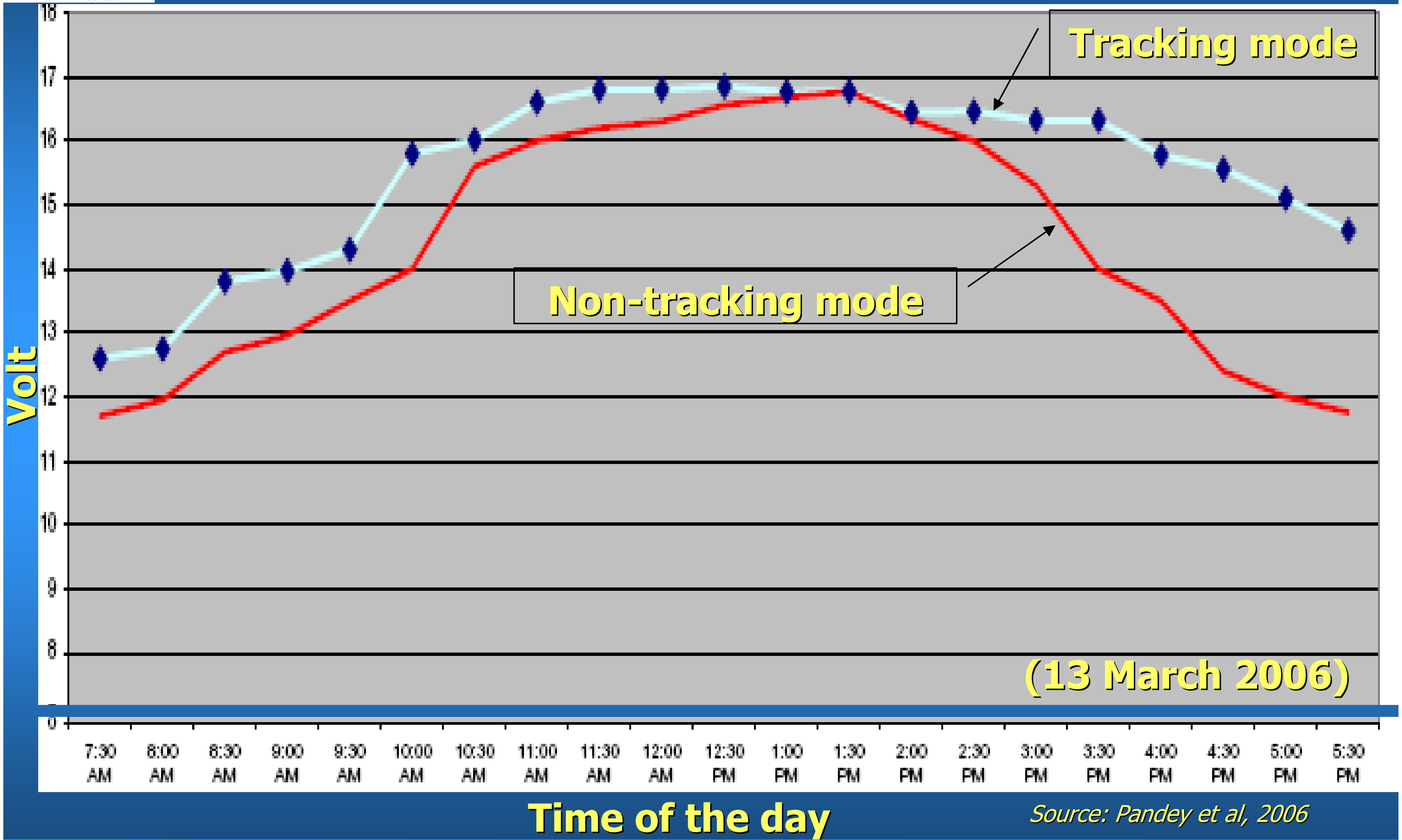
- **Main sensors tracks sun**
- **Secondary sensor causes the tracker return to original position in the morning**
- **5 V OCV is enough to track the sun at around 30 min interval**
- **45 W SHS provides energy for 3 WLED (3 W) for 5 hours/day**
- **17 household can be benefited**
- **Cost ~ 400 €/system with WLED**

Source: Pandey et al, 2006

Photo: Maskey, 2005

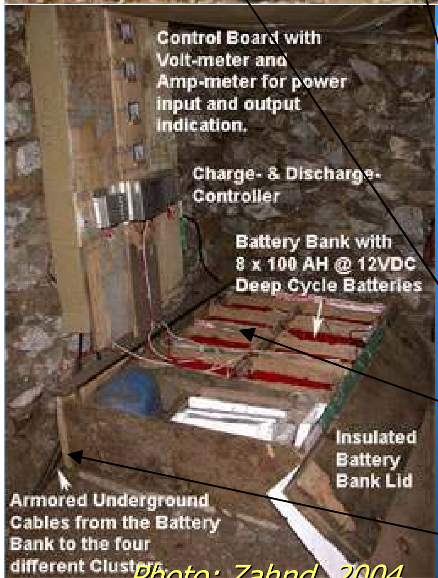
Photo: Maskey, 2005

Energy gain due to tracking mode



Source: Pandey et al, 2006

High-altitude Research Station of Kathmandu University



Features:

- Four four-module 300 watt SHS with self-tracking system
- KU's Solar water heater Instrumentation
- Solar cookers SK-14
- Six-battery bank 8 x 100 AH @ 12 VDC
- Armoured cable

- **Basic criteria:**
  - Solar insolation (W/m²) at the site
  - Load growth pattern
  - Reliability for operation and maitenance
  - Prefer well-proven locally manufactured parts
  - Least cost solution
  - Greater participation of stakeholders
  - Culturally appropriate and sustainable training
  - Zero ecological impact

Projects grown out of successful student research projects

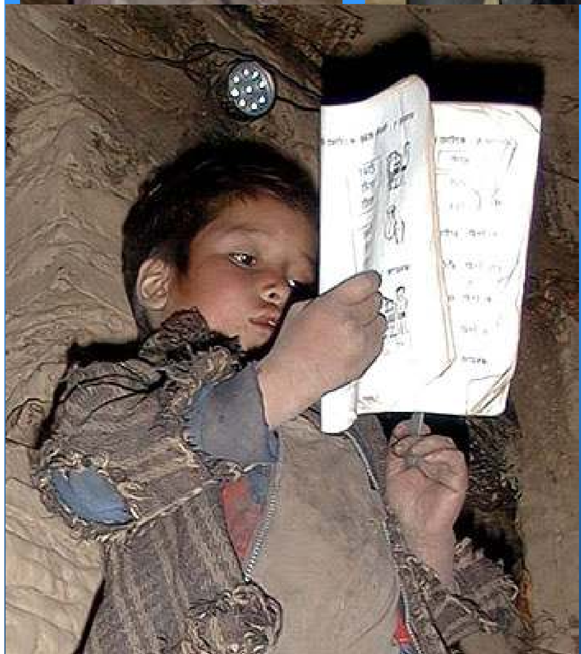
Project area	RAPS Technology	Benefi-ciary	Remarks
Chauganphaya Humla Load 300 Watt	▪ Four 75 Watt Self-tracked SHS ▪ Three 1-Watt WLED/HH ▪ Underground cable ▪ 12 V Battery bank (six 100 AH)	63 HH	▪ Smokeless stove ▪ Pit latrine ▪ Drinking water system
Kholsi village Humla Load 250 Watt	▪ Pico-hydro ▪ 1000 W ▪ Three 1-Watt WLED/HH ▪ Warm water heating system	60 HH	▪ Two rod heaters (700 and 300 Watt) ▪ Electronic load controller

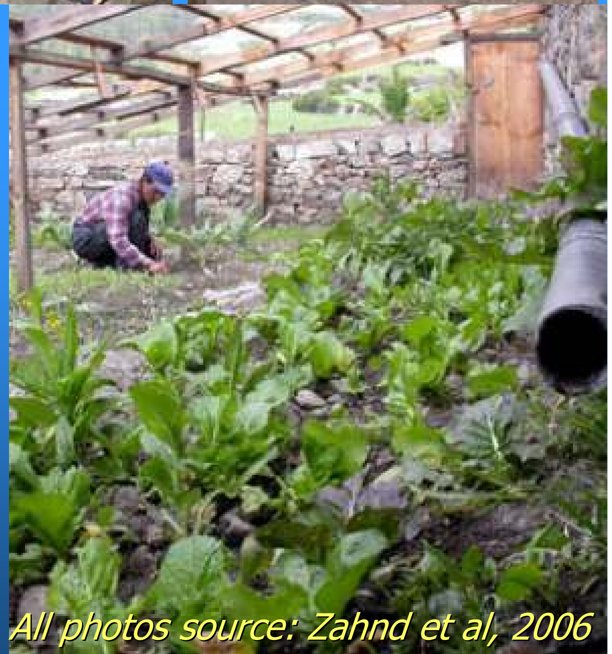
Source: Zahnd, 2004

Project implementation process

All photos source: Zahnd et al, 2006

Holistic community development





All photos source: Zahnd et al, 2006

Observation and Conclusion

- RAPS System: crucial for rapid rural electrification
- Basic needs: Lighting-smokeless stove-clean water-latrine
- RET project should be integrated with HCD projects
- RET must be tested well on site for community acceptance
- Key aspects: appropriateness and sustainable
- Need for more High-altitude research stations of KU
- PV-based self-tracking system achieves 40% of power gain
- PV-based self-tracked RAPS system: a cheap solution
- Design of control system to follow sun during cloudy days
- Possibility for PV-Wind-hydro hybrid system: research area for KU

RET-based Rural Electrification

Thank you

for your kind attention!

Namaste!

- **Acknowledgement to:**
  - Prof. Dr. Bim Shrestha and Student-research team-Pandey et al, KU
  - DAAD and Organizing committee of Summer School