



Modelling for Energy Planning and Policy Analysis for Nepal

Joint TERI – ETSAP Workshop

Energy Modelling Tools & Techniques to address Sustainable Development & Climate Change

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Outline of Presentation

- 1) Introduction
- 2) Current Energy Sector Situation
- 3) Major Issues
- 4) Renewable energy resources potential
- 5) Modelling Framework: MAED & MARKAL
- 6) Future Energy Scenario Analysis
- 7) Major Policy Recommendations & conclusion

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Introduction



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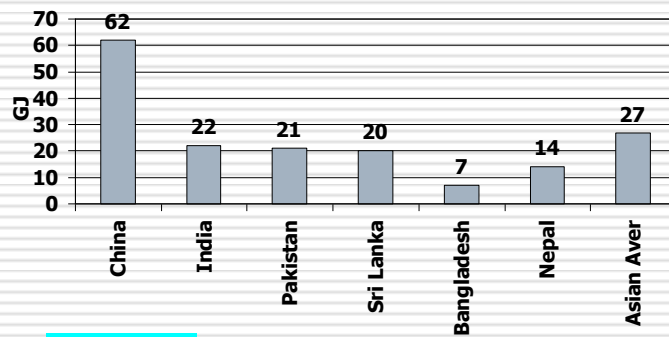
The world's energy system is at a crossroads. Current global trends in energy supply and consumption are patently unsustainable – environmentally, economically, and socially. But that can – and must – be altered; there is still time to change the road we are on.

- World Energy outlook, 2008

IEA

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Per Capita Primary Energy Supply in 2007

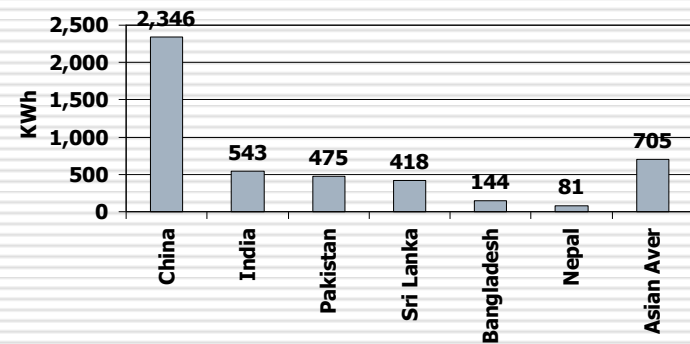


1 toe = 41.87 GJ

Key World Energy Statistics, IEA, 2009

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Per Capita Electricity Consumption in 2007



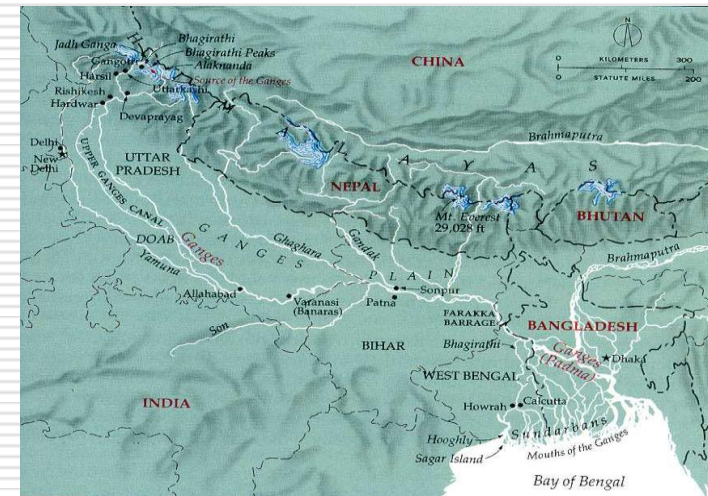
Key World Energy Statistics, IEA, 2009

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Brief Introduction on Nepal

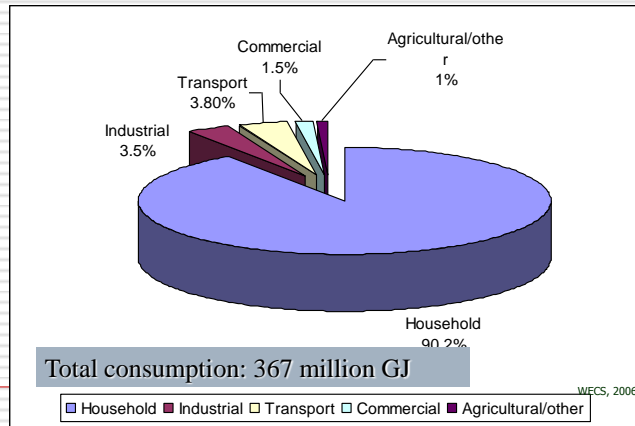
- Population 28.11 million
- Per capita GDP US\$ 246
- Area 147,000 sq km
- Length 880 km (East-West)
- Breadth 145 to 241 km (North-South)

Key World Energy Statistics, IEA, 2009



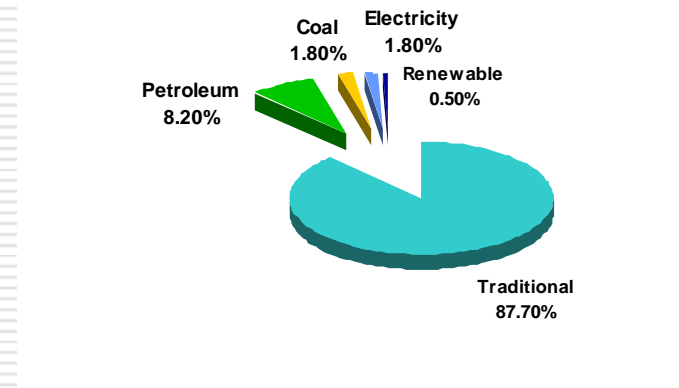
DOED, 2006

End-use Consumption of Energy in Different Sectors in 2005



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Energy Consumption in 2005

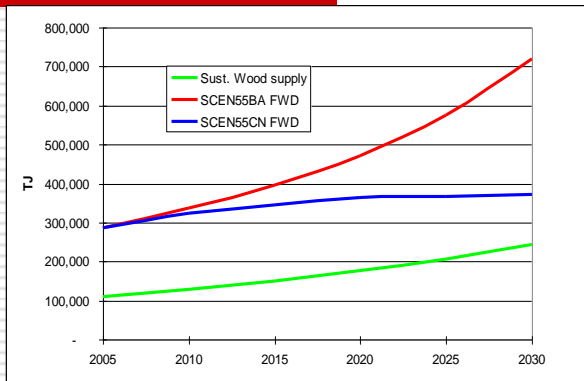


Total Energy Consumption 367 million GJ

WECS, 2006

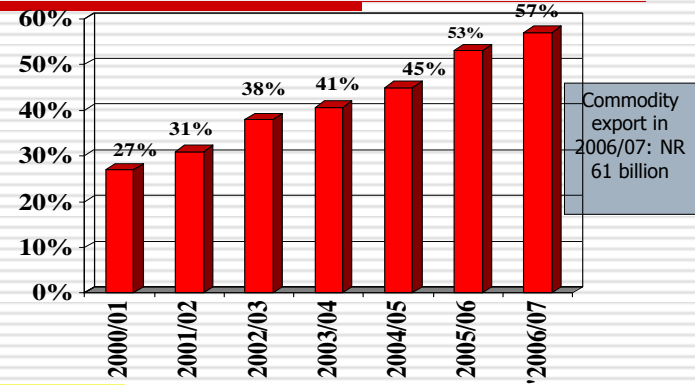
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Fuelwood requirement against sustainable supply (in TJ at 5.5% GDP growth rate)



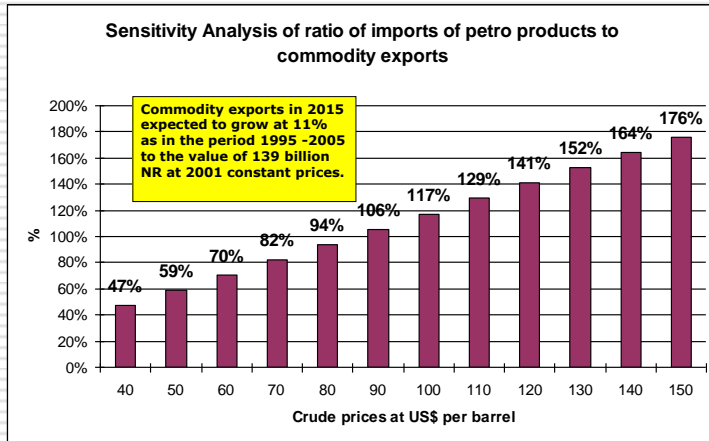
Calculations based on MARKAL output & WECS, 2006 & Forestry Master Plan, 1988.

Import of Petroleum Products against Commodity Exports



1 US\$ = NR 73.00

Economic survey, GON, 2007/08



Calculation based on ADB statistics on Nepal, 2008.

1 US\$ =NR 73.00

Monthly household life cycle costs of cooking in different fuels (based on D'sa and Murthy, 2004) **NRs**

Year	Kerosene	LPG	Electricity
1997	180	465	605
2000	385	405	680
2003	410	510	788
2009*	912	794	788
Economic cost	862	853	

* At price adjustment in March 2009 (NOC, 2009)

US\$ 1 =NR 73.00

Electricity price at NR7.30/unit

Current LPG Price: loss of NR 87/cyl (Sept. 2009)

Sales of petro-products in 2009

Petro-products	Sales in KL/MT	% growth from 2008
Gasoline	124,169	22%
Diesel	446,468	46%
LPG MT	115,813	24%
Kerosene	70,089	-65%
Total petro-products	828,022	14%

Source: NOC, 2009

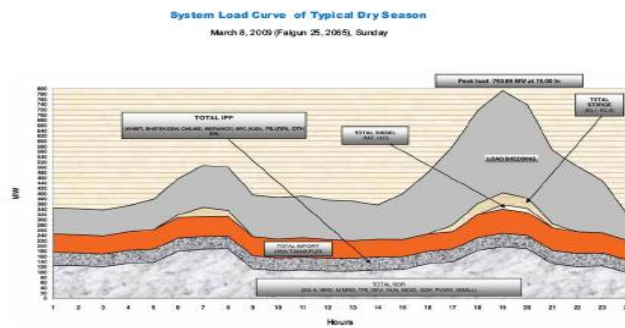
Electricity sales and expected demand in 2010

	Expected demand in 2010 GWh	Sales in 2009 GWh	Deficit in %
Expected demand/sales	4,018	2,309	43%

1 GWh = 1 million KWh (units)

Source: NEA, 2009

Load Curve on 8 March, 2009 (NEA)



Expected powercuts a day: 12 hours in dry season in 2010 (March- June)

Major Issues in energy sector

- Consumption of traditional fuels - unsustainable
- Dependence on imported petroleum products - too much
- Harnessing of the indigenous hydropower resources - very poor
- Fuel substitution - strongly needed

Energy Resources Potential

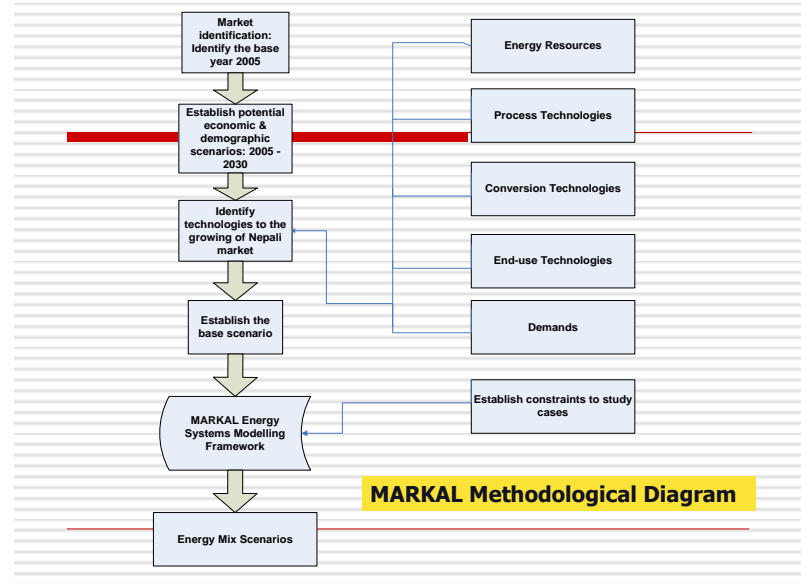
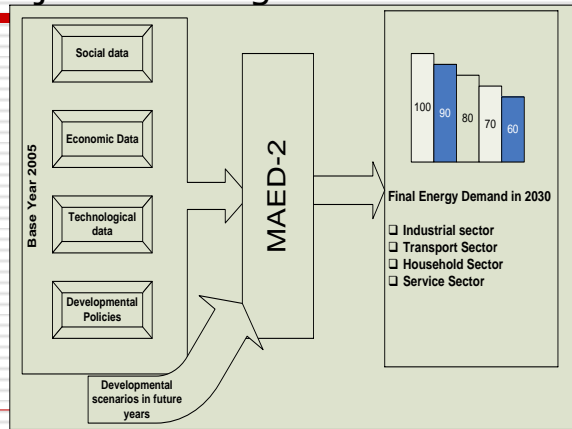
Renewable energy sources	Theoretical potential MW/MWa	Economical potential MW/MWa	Utilized MW/units	% of utilization
Hydropower	83,000	42,000	688	1.6
Microhydro	50		10.2	20
Solar PV power plant	9,750			0
Solar PV home system	122		3.2	3
Wind Power	1,215			0
Biogas plant (MWa)	864		60	7
Solar water heating Urban (MWa)	82		23	28

Based on NEA, 2009; WECS, 2006; AEPC, 2008 and author's calculations

Methodology

- Useful Energy Demand Projection using Model for Analysis of Energy Demand (**MAED**) developed by International Atomic Energy Agency (IAEA), Vienna, Austria.
- Energy Supply System Analysis using **ASWER MARKAL** developed by Energy Technology Systems Analysis Programme (ETSAP), International Energy Agency (IEA), Paris, France.

End-use Approach for demand projection using MAED-2



Methodology

- Participatory workshops for issues identification
- Collection of data from WECS, CBS, MOF, MOF&SC, NPC, NEA, NOC, World Bank, ADB, UN, ESMAP etc.
- Analysis/Time horizon : from 2005 to 2030
- Macroeconomic indicators –
 - GDP growth rate - 4.3 percent (average)
 - GDP growth rate – 5.5 percent
 - GDP growth rate - 7.0 percent
- Demographic parameter – population growth rate: medium variant growth rate (leading from 2.23 percent to 1.74 percent in 2020 and onwards; CBS, 2003)

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Future Energy Scenario



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Scenarios (Policy Interventions at Reference Case)

□ Introduction of Clean Energy Technology at Reference Case

- Traditional fuels and fossil fuels replaced by electricity and/or fossil fuels.

Sub-sector	2020	2030
Industrial and commercial	Traditional and fossil fuels decreased by 20%	*Decreased 30%
Residential Urban	Fuelwood share decreased by 50%	*Decreased by 75%
Residential Rural	Fuelwood share decreased by 10%	*Decreased by 30%

*replaced by electricity, kerosene & LPG 28

Scenarios - Policy Interventions at Reference Case

□ CFL Penetration

- Incandescent bulbs replaced by CFLs at the rate of 50 percent in 2020 and then linearly to 100 percent in 2030 industrial, commercial and residential sectors.
- Transmission and distribution losses of electricity grid reduced from 25 percent in base year to 20 percent in 2015, and then linearly to 10 percent in 2030

*replaced by electricity, kerosene & LPG 29

Scenarios - Policy interventions at reference case

- Introduction of New Transportation Technology :
 - Ethanol and bio-diesel mixing in petrol and diesel respectively. Ethanol mix 10 percent 2020 onwards and 20 percent in 2030. Bio-diesel mix 5 percent 2020 onwards and 10 percent in 2030, and
 - Electric and hybrid cars introduced. Diesel and petrol cars to be reduced by 10 percent of reference case in 2020, 20 percent in 2025, and 30 percent in 2030.
 - Electric cars will be substituting at the rate of 5 percent in 2020, 10 percent in 2025, and 15 percent in 2030.
 - Hybrid cars will be substituting the remaining as 5 percent in 2020, 10 percent in 2025, 15 percent in 2030.

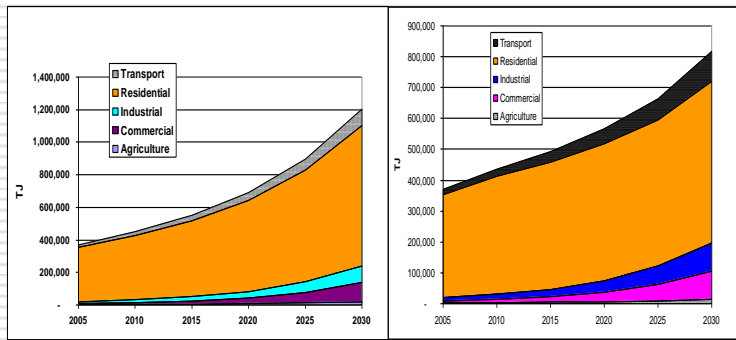
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Scenarios - Policy interventions at reference case

- All combined policy measures:
 - All combined policy measures plus wind power plant and solar water heating system introduced.

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Energy consumptions in reference and combined policy cases

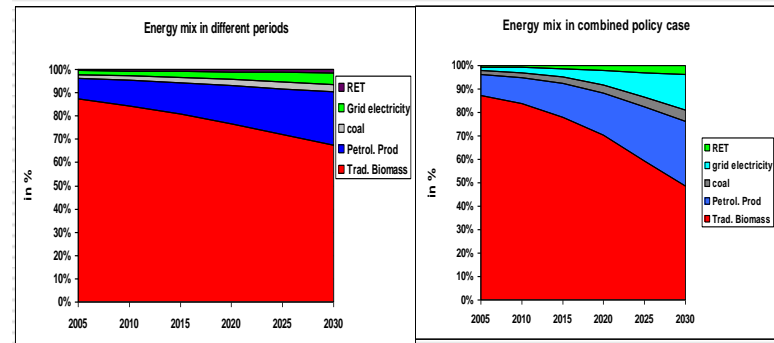


Reference case

Combined case

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Fuel Mix at Reference & combined policy cases

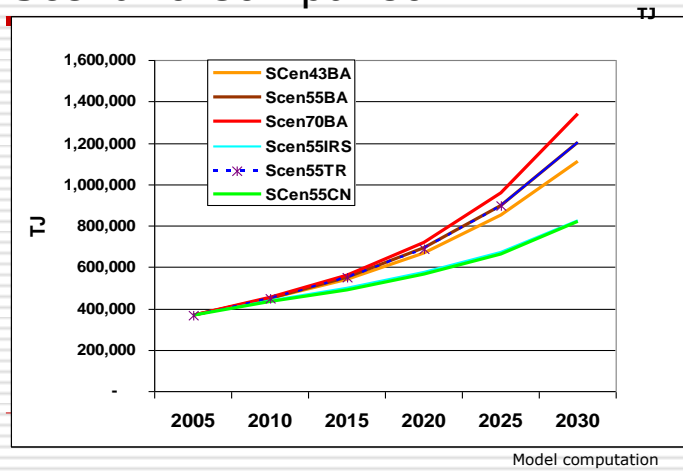


Reference case

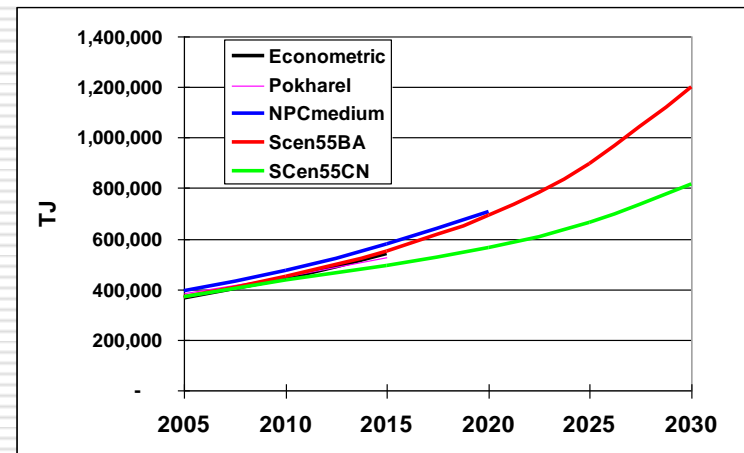
Combined case

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Scenario Comparison



Comparison with other models



Sustainable Energy Indicators in Reference Case Scenario

Indicators	Units	2005	2010	2015	2020	2025	2030
Final energy consumption/capita	GJ/capita	15	16	18	21	25	30
Electricity consumption/capita	kWh/capita	67	87	123	183	297	423
Energy Intensity	GJ/1000\$	54	51	48	46	45	46
Electricity intensity	kWh/1000\$	247	275	327	406	546	641
Electricity power utilized	per cent	1%	3%	4%	7%	11%	18%
Total Energy Consumption/ value added in industrial sector	GJ/1000\$ value added	23.7	23.9	26.7	31.0	38.4	43.9
commercial energy / value added	GJ/ Bill Nrs	29,701	41,858	59,502	85,059	121,904	174,837
Total Energy Used/household	GJ/HH	76.1	81.6	87.6	95.8	107.2	123.3
Electricity used/HH	kWh/HH	177	261	372	536	774	1,115
Transport Energy Utilization	GJ/M T-km	1.3	1.9	1.9	1.9	2.0	2.0
Transport Energy Utilization	GJ/M P-km	0.4	0.5	0.5	0.5	0.5	0.5
share of non-carbon energy in primary supply	per cent	1.7%	1.99%	2.52%	3.29%	4.52%	5.27%
Share of renewable energy in final total energy consumption	per cent	2%	3%	3%	4%	6%	6%
the ratio of net import to total primary energy supply	per cent	10%	12%	15%	18%	21%	25%
GHG emission for every ton of energy production and use	GHG in Kg/capita	806	895	1,006	1,157	1,376	1,690

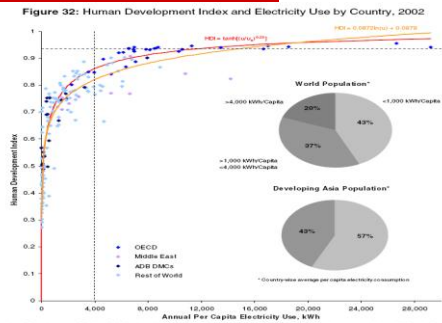
USD 1.00 = NR 73.00

Sustainable Energy indicators for combined case

Energy Indicators	Units	2005	2010	2015	2020	2025	2030
Final energy consumption/capita	GJ/capita	15	16	16	17	18	21
Electricity consumption per capita	kWh/capita	67	99	158	282	533	882
Energy Intensity	GJ/1000\$	54	49	43	38	34	31
Electricity Intensity	kWh/1000\$	249	313	444	663	1,026	1,382
Electricity power utilized	per cent	1%	2%	4%	7%	13%	23%
Total Energy Consumption/ value added in industrial sector	GJ/1000\$ value added	24	24	26	30	36	41
commercial energy / value added	GJ/ Bill Nrs	29,701	41,153	54,388	72,285	98,539	134,756
Total Energy Used/household	GJ/HH	76	79	77	76	74	75
Electricity used per HH	kWh/HH	177	261	475	853	1,549	2,552
Transport Energy Utilization	GJ/M T-km	1	2	2	2	2	2
Transport Energy Utilization	GJ/M P-km	0.4	0.5	0.5	0.4	0.4	0.4
share of non-carbon energy in primary supply	per cent	1.7%	2.3%	3.7%	6.3%	11.0%	15.9%
Share of modern renewable energy in final total energy consumption	per cent	2%	3%	5%	8%	14%	19%
the ratio of net import to total primary energy supply	per cent	10%	12%	16%	20%	25%	31%
GHG emission for every ton of energy production and use	GHG in Kg/capita	806	859	894	936	977	1,069

HDI and per capita electricity consumption (ADB, 2007)

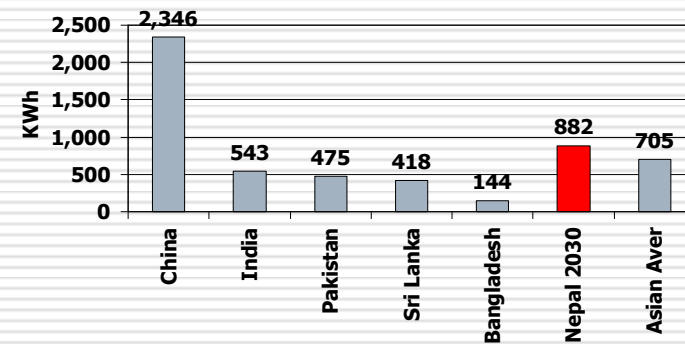
2,000 kWh per capita is needed to achieve HDI of 0.8.



ADB = Asian Development Bank; DMG = developing member country; HDI = human development index; kWh = kilowatt-hour; OECD = Organisation for Economic Co-operation and Development.
 Asian refers to Substrate 11 for correlation curves.
 Source: United Nations Development Programme (UNDP), 2006. Human Development Reports. New York; UNDP. Available: <http://hdr.unep.org/statistic/data>

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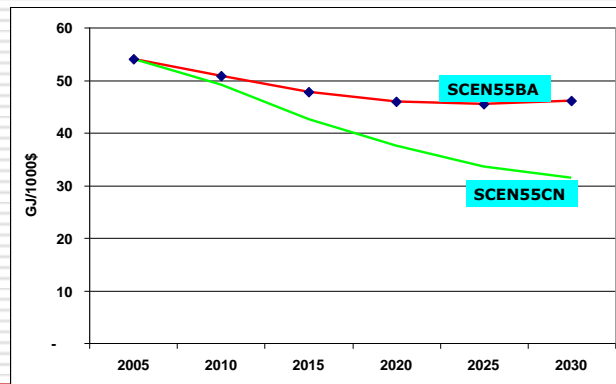
Per Capita Electricity Consumption in 2007



Key World Energy Statistics, IEA, 2009

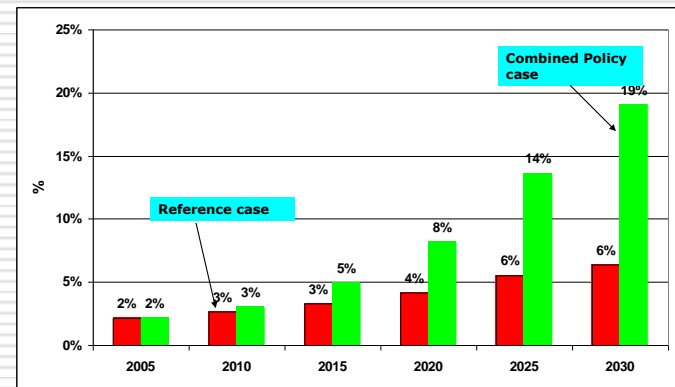
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Energy Intensity



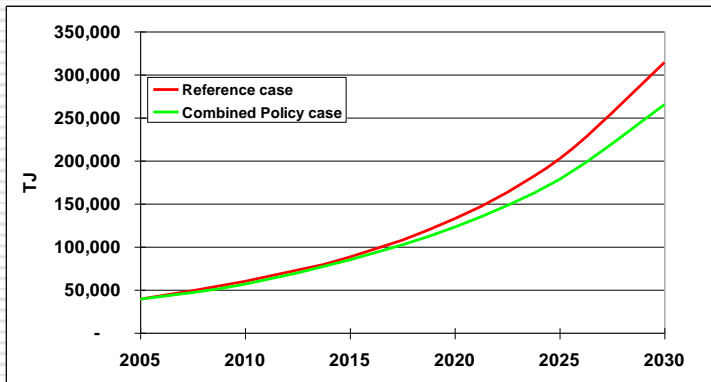
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Share of Renewable Energy in Total Final Energy



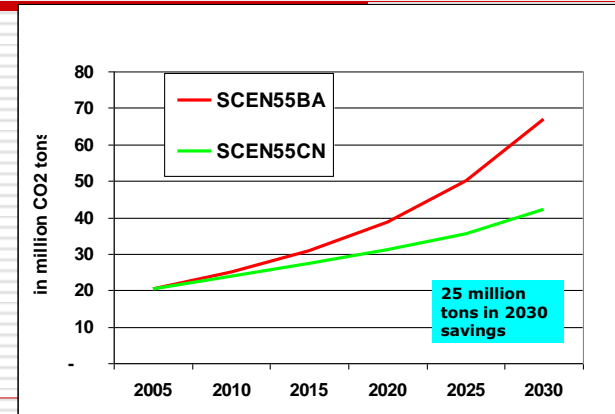
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Net Imports to Total Energy Consumptions



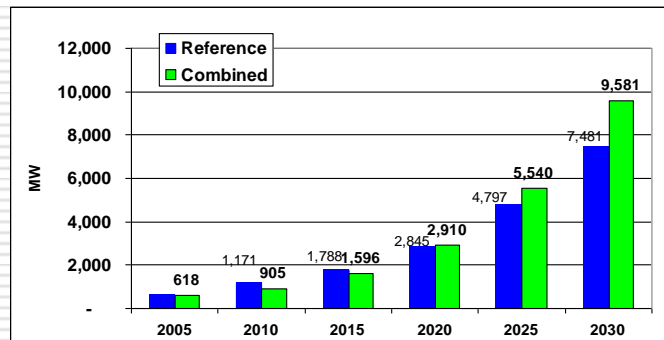
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GHG Emissions in CO₂ equivalent

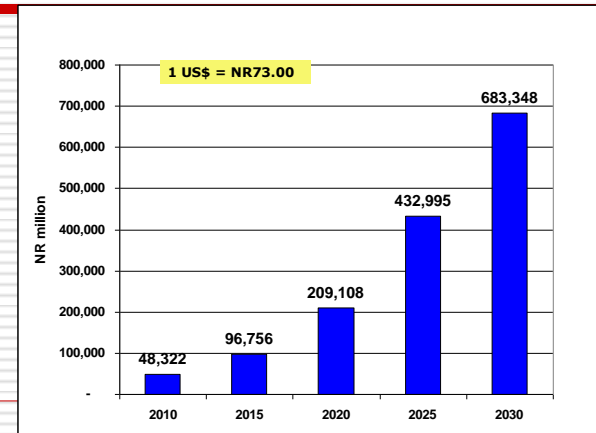


12 billion NR through carbon trading (164 million USD) in 2030.

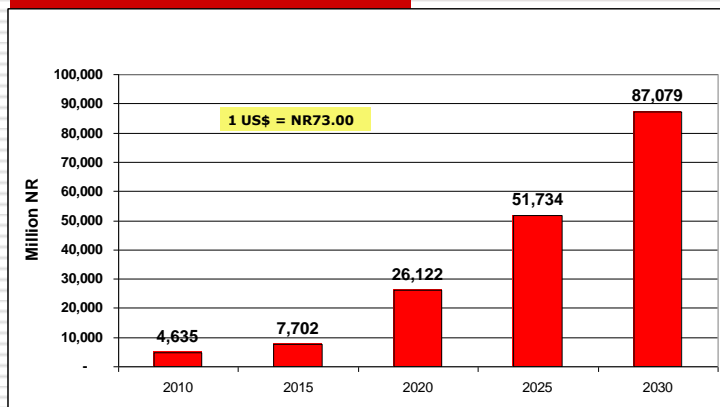
Power Plant Installed capacity



Total undiscounted supply investments



Undiscounted Investment in RET



Major Policy Options



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Major Policy recommendations & conclusion

- Discourage use of fossil fuels
 - Prioritize indigenous hydropower as lead energy resources
 - Promote energy efficiency program
 - Emphasize on renewable energy technology
 - Deregulate energy sector
 - Regional cooperation with SA countries
 - Further improvement/development of MARKAL model and MARKAL-MACRO
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Thank you !
