AFRICAN UTILITY WEEK | CLEAN POWER AFRICA

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Basic Principles of Least- Cost Planning & Regional Interconnection in EA Countries

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Map of Kenya


SUDAN
ETHIOPIA
SOMALIA
UGANDA
TANZANIA
KENYA
BIOMAS
OIL EXPN
HYDRO
WIND
± 500 kV HVDC
400 kV ac.
GEOTHERMAL
HYDRO
BIOMAS
COAL
BIOMAS
Lake Victoria
Nairobi
Galana
Malindi
Mombasa

Basic Rules that govern Least Cost Planning

- Load forecasting must be realistically prepared based on historical trends and future economic growth.

- Peak demand (in MW) must be met with effective installed capacity and about 20% reserve margin. Also, largest single plant must not be more than 10% of base load, or 5% of Peak demand.

- Annual Energy demand (in GWh) must be met with minimum hydro energy available in a critical drought year.

- Generation mix and siting of plant must be based on least cost criteria, and projects must be completed on a timely basis

LOAD FORECASTING

Why most African Countries project high load growth figures

- Usually to woo international Donor Agencies and foreign Investors

- To guard against financing and other implementation delays.

- To conceal certain plant and operational deficiencies.

- To promote some pet energy programme or install certain ‘white elephant’ projects.

Load Forecasting

Projected Peak and Energy Demand FYE 2014-2030

	14/15	15/16	16/17	17/18	18/19	19/20	20/21	21/22	22/23	23/24	24/25	25/26	26/27	27/28	28/29	29/30
Basic Demand(MW) 7.00% Gr	**1,600**	**1,700**	**1,810**	**1,930**	**2,060**	**2,190**	**2,330**	**2,480**	**2,640**	**2,820**	**3,000**	**3,400**	**3,600**	**3,900**	**4,150**	**4,500**
VISION "2030" FL/ Sh Projects																
ICT Cities	10	20	20	30	30	40	50	60	60	80	90	110	140	160	180	**200**
Lamu Port/Lapset	10	10	20	30	40	50	50	60	60	80	100	120	150	200	250	**300**
Railways		10	10	10	40	40	40	40	60	70	80	90	110	160	180	**200**
Mining Industries		10	20	20	40	70	100	120	140	160	200	240	300	340	370	**400**
Other Industry	20	30	30	30	40	70	100	120	140	160	200	240	300	340	370	**400**
Total FL/SH Projects	**40**	**80**	**100**	**120**	**190**	**270**	**340**	**400**	**460**	**550**	**670**	**800**	**1000**	**1200**	**1350**	**1500**
Total Demand (MW)	**1,640**	**1,780**	**1,910**	**2,050**	**2,250**	**2,460**	**2,670**	**2,880**	**3,100**	**3,370**	**3,670**	**4,200**	**4,600**	**5,100**	**5,500**	**6,000**
Ann. Energy @0.69LF (GWh)	**9,913**	**10,759**	**11,545**	**12,391**	**13,600**	**14,869**	**16,139**	**17,408**	**18,738**	**20,370**	**22,183**	**25,386**	**27,804**	**30,826**	**33,244**	**36,266**

Av. Annual Load Growth = 9.0%

Correlation between GDP & Load Growth

FYE	GDP Grth %	Load Grth %
1993 – 1998	3.5	3.8
1998 – 2003*	1.2	2.0
2003 – 2008	5.2	5.9
2008 – 2013	4.5	5.2
Av. Growth %	**3.6**	**4.3**

** Kenya suffered a 3yr critical drought during 1998/99/2000*

Av. Correlation between load growth & GDP = 1.20

Reserve Margins

- At least 20% Reserve Margin should be maintained to cater for
  - 10% - Planned Outage
  - 5% - Forced Outage
  - 5% - Spinning Reserve

- Maximum size of single plant must not be more than 10% of base load or 5 % of peak demand, for operational reasons.

- Import should be ideally restricted to no more than 20% of installed capacity, to maintain security of supply.

Minimum Hyrdo Energy Available

- A comprehensive flow data for all hydro stations must be kept for at least 50 years.

- A 'critical drought rule curve' must be strictly followed for all large reservoirs, to maintain adequate storage capacity in a very dry year.

- Hydro Energy Available for the current Kenya system in an average year is about 3,600 GWh per annum.

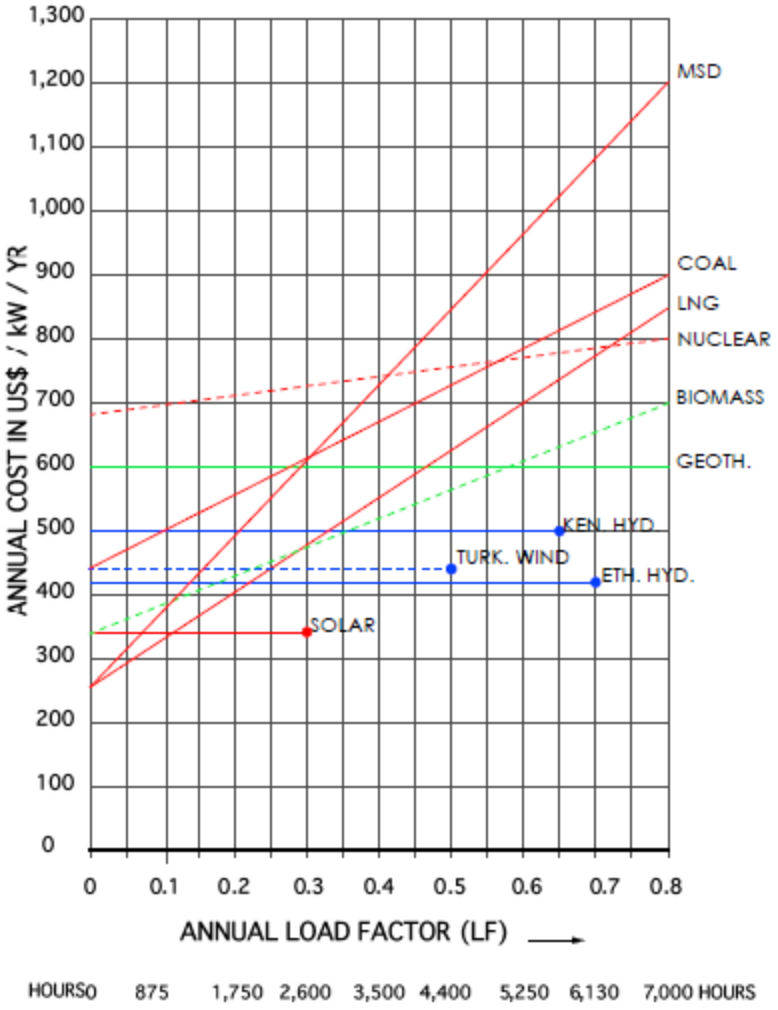
- In a critical drought year minimum energy available is 2,800 GWh.

- Hence adequate thermal plant to provide at least 800 GWh must be available on stand by in a drought year.

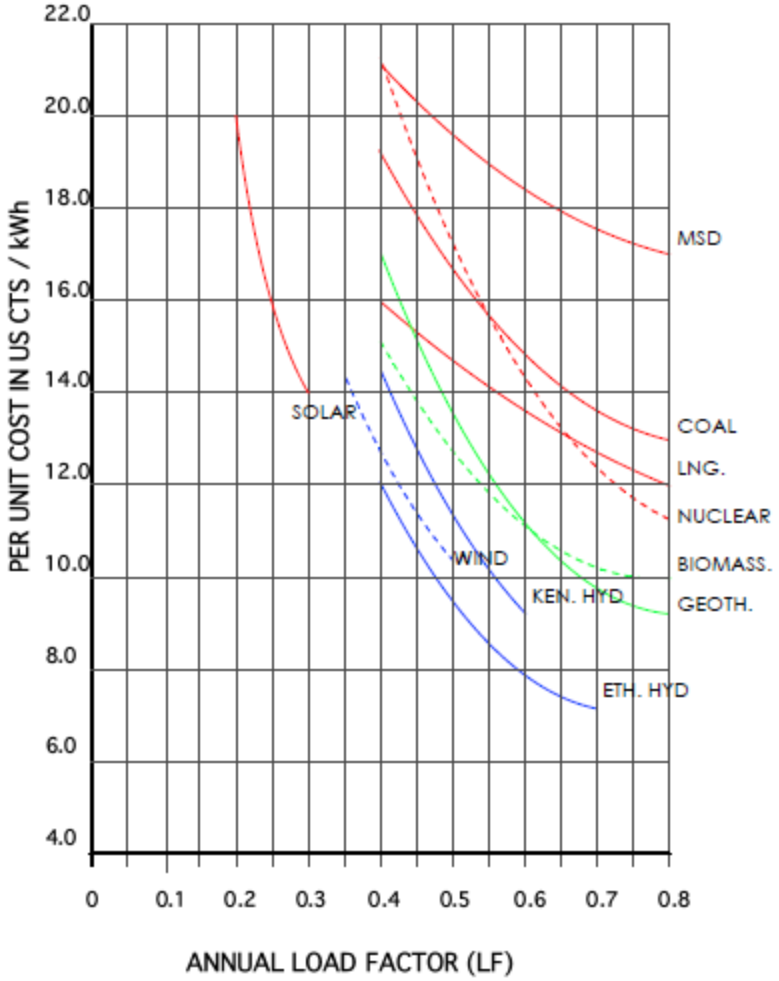
Summarized Cost of Gen. in Uscts/kWh at 10% DCF

Gen. Source	Capacity MW	Available Plant LF	Range of Costs Uscts/kWh
HYDRO Gibe IV (Eth) Low Gr. Falls (Ke)	1,470 140	0.44 0.55	7.0 – 8.0 11.0 – 12.0
GEOTHERMAL (Convnl) (Well-Hd)	70 10	0.80 0.80	9.0 – 10.0 8.0 – 9.0
WIND (Turkana) (Others)	300 60	0.50 0.35	9.0 – 10.0 11.0 – 13.0
BIOMASS (Juliflora)	20	0.80	10.0 – 11.0
SOLAR, PV	20	0.20 – 0.25	15.0 – 18.0
BIO–SOLAR HYBRID	20	0.80	11.0 – 12.0
COAL (Imported)	300	0.80	13.0 – 14.0
NATURAL GAS (Tz)	240	0.80	9.0 – 10.0
MSD, (HFO)	100	0.80	17.0 – 18.0
NUCLEAR	1,000	0.80	11.0 – 12.0

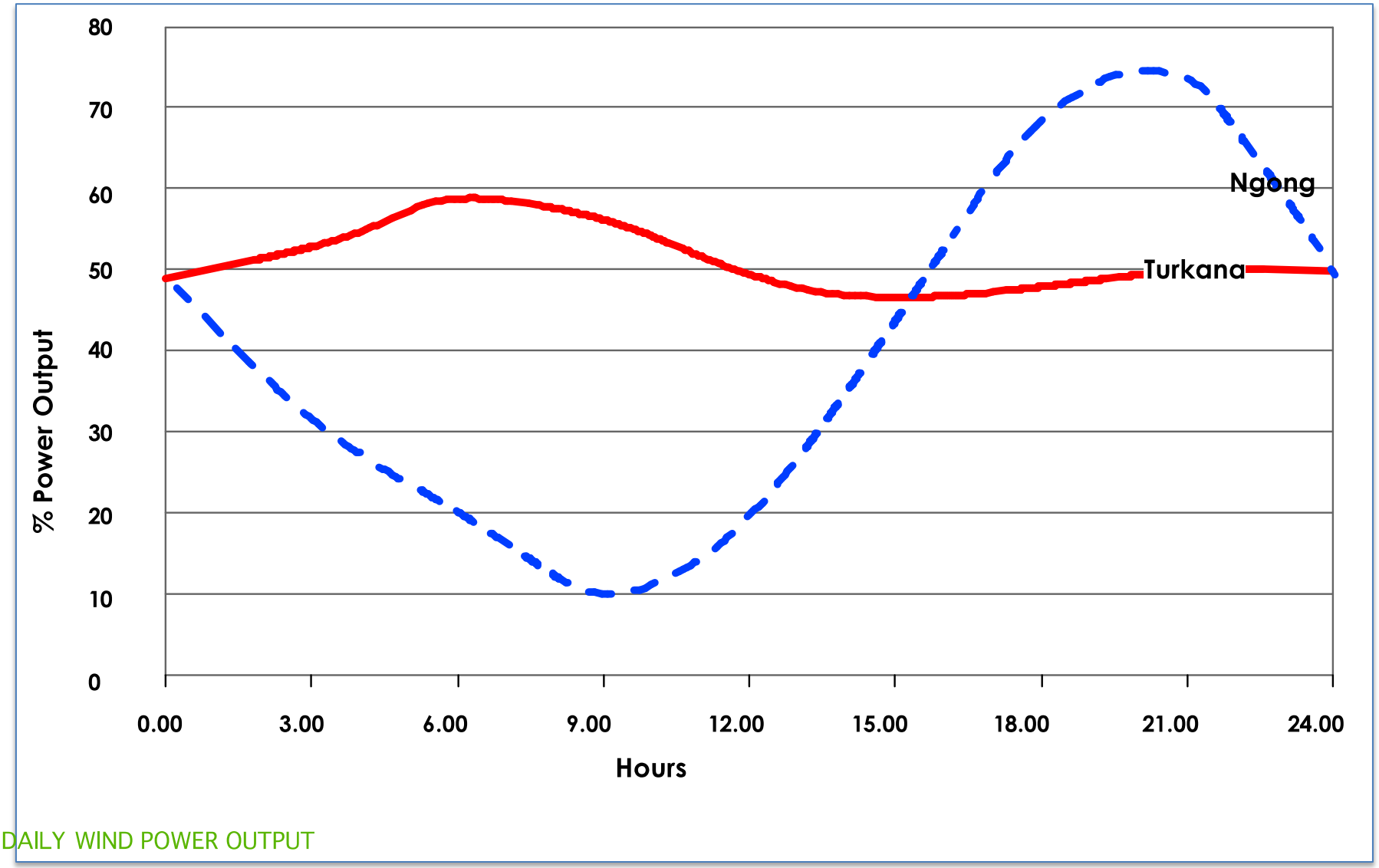
COMPARATIVE ANNUAL COSTS IN US$/kW/YR AT DIFFERENT LF



COMPARATIVE ENERGY COSTS IN US CTS/kWh AT DIFFERENT LF

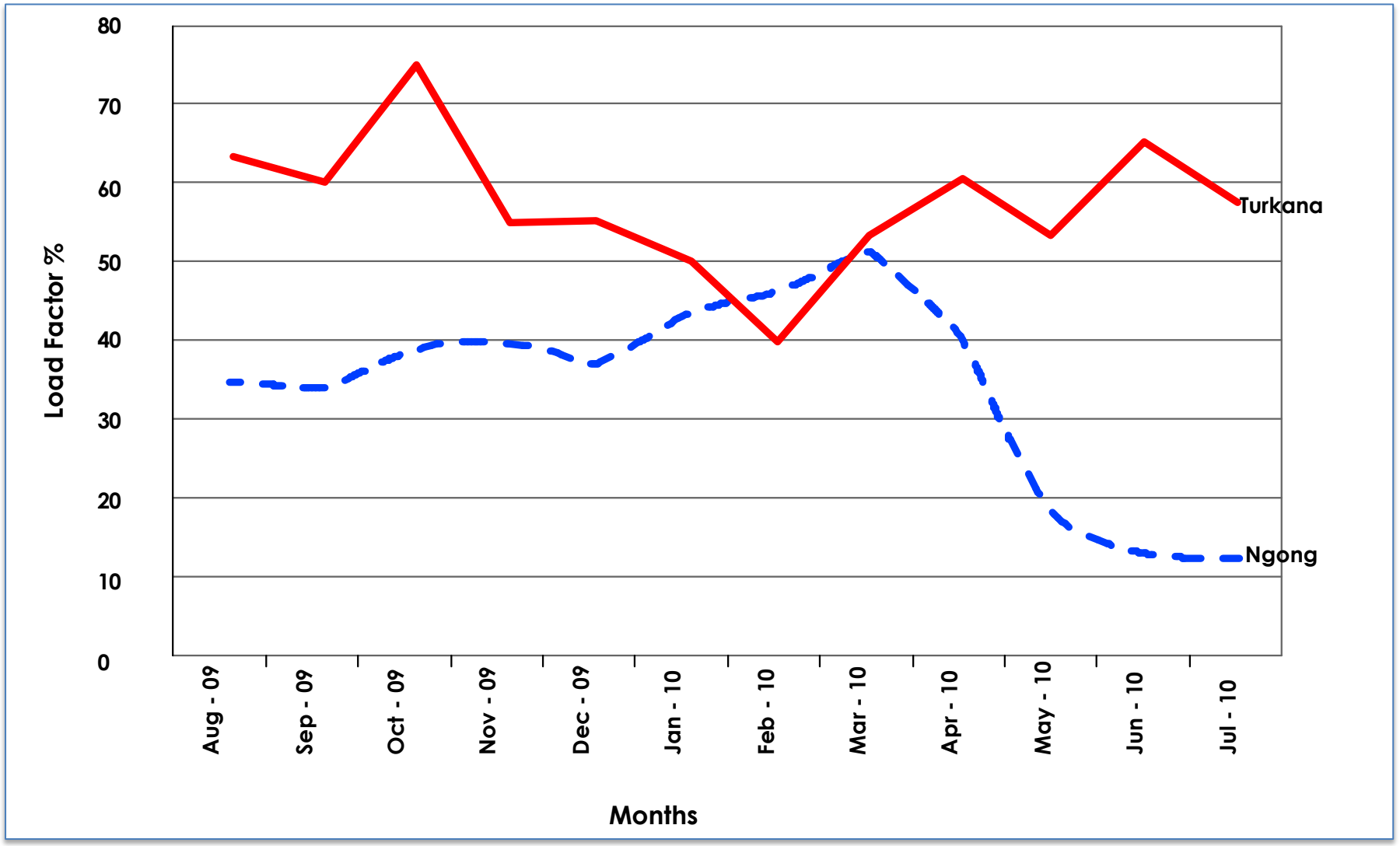


Daily Wind Power Output



DAILY WIND POWER OUTPUT

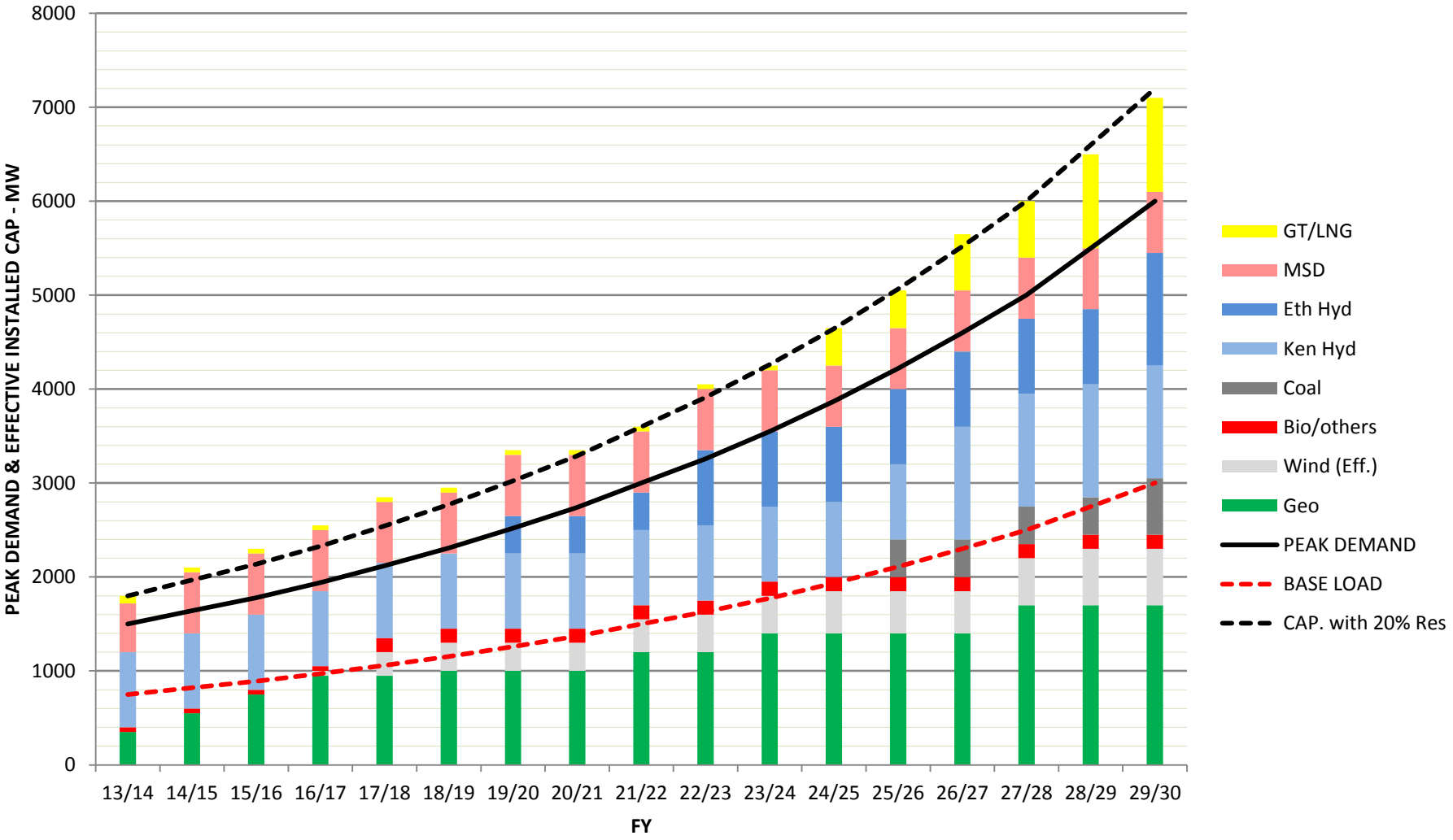
Monthly Wind Power Output



INDICATIVE LEAST COST PLAN (FYE 2014-2030)

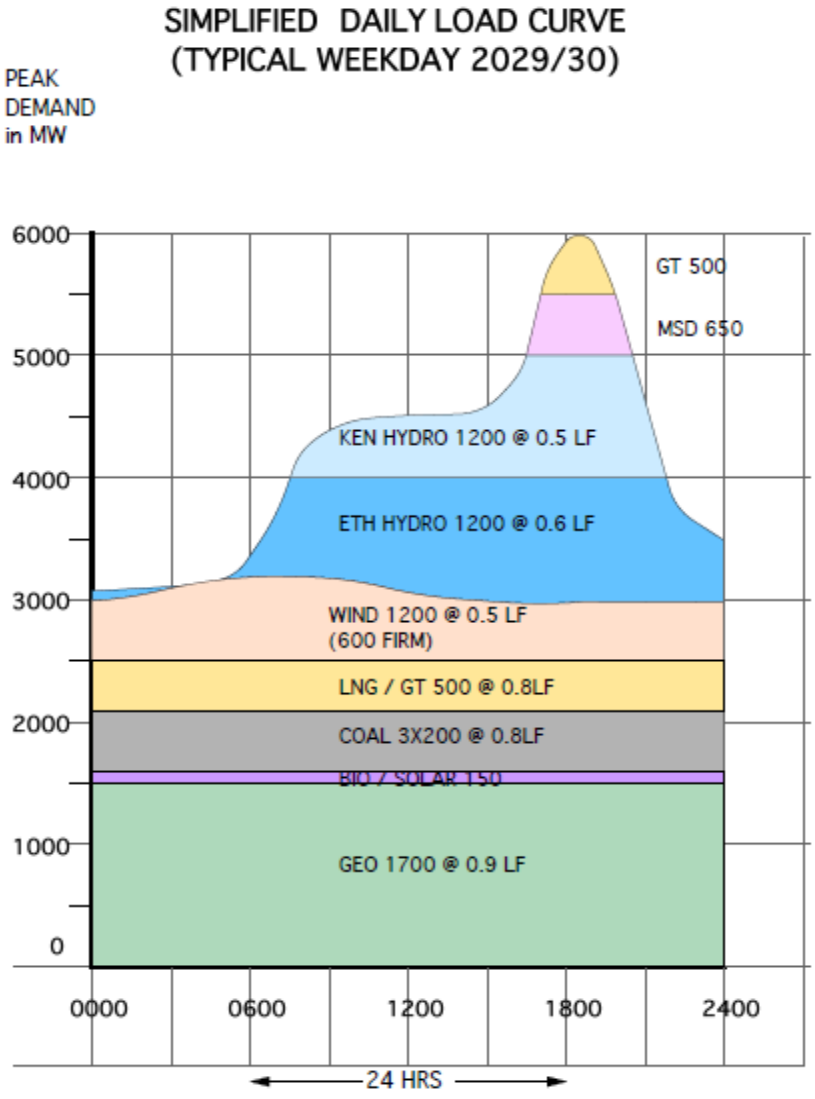
FY	PLANT	EFF. ADDL CAP. MW	EFF. INSTAL CAP MW	PEAK DEMAND MW	FY	PLANT	EFF. ADDL CAP. MW	EFF. INSTAL CAP MW	PEAK DEMAND MW
13/14	GEO BIO/ OTHERS Ken. HYDRO HSD GT/EMP.	350 50 800 520 80	1800	1500	21/22	GEO WIND 100	200 50	3600	3000
					22/23	WIND 100 ETH. HYDRO	50 400	4050	3260
14/15	GEO MSD Retire EMP	200 130 (30)	2100	1640	23/24	GEO	200	4250	3550
15/16	GEO	200	2300	1780	24/25	WIND 100 GT/LNG Retire GTs	50 400 (50)	4650	3870
16/17	GEO WIND 100	200 50	2550	1940	25/26	COAL PLANT	400	5050	4220
17/18	WIND 400 BIO/OTHERS	200 100	2850	2120	26/27	Ken. HYDRO GT/LNG	400 200	5650	4600
18/19	GEO WIND 100	50 50	2950	2310	27/28	GEO WIND 100	300 50	6000	5000
19/20	ETH. HYDRO	400	3350	2520	28/29	WIND 200 GT/LNG	100 400	6500	5500
20/21	NIL	0	3350	2740	29/30	COAL ETH. HYDRO	200 400	7100	6000

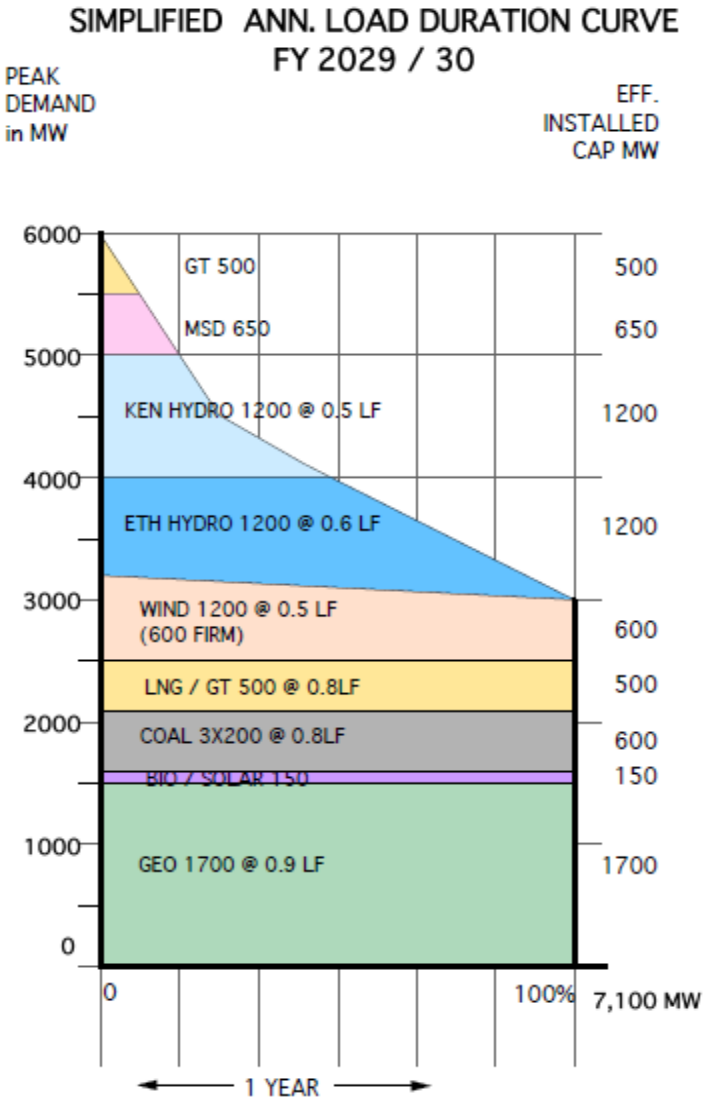
Projected Peak Demand & Installed Capacity in MW
FYE (2014 - 2030)



Projected Energy Demand & Energy Available in GWh
FYE (2014 - 2030)

SIMPLIFIED
DAILY LOAD & ANN. LOAD DURATION CURVES





REGIONAL INTERCONNECTION

- In future base load in East African countries will be supplied by renewable resources like geothermal, wind, bio/solar, and LNG.

- The variable load will be supplied by hydro energy.

- The peak load will be met by thermal energy.

- Once all the East African countries are interconnected, they should then exchange power appropriately, at the most economic costs.

Projected Electricity Tariff in Kenya (UScts/kWh)

	Actual	Projected					
FY	**12/13**	**13/14**	**14/15**	**15/16**	**16/17**	**17/18**	**18/19**
Gen. Cap Cost	6.0	6.5	7.0	7.0	8.0	8.0	8.5
Gen. Fuel Cost	5.5	6.0	4.5	4.0	2.5	2.5	1.5
Total Gen. Cost	**11.5**	**12.5**	**11.5**	**11.0**	**10.5**	**10.5**	**10.0**
T & D Cost	5.5	5.5	5.5	5.5	5.5	5.0	5.0
Total Cost	**17.0**	**18.0**	**17.0**	**16.5**	**16.0**	**15.5**	**15.0**

Comparison of Economic Cost of Electricity in EA Countries (FY10/11)

	Cost in UScts/kWh			
	KENYA	**UGANDA**	**TANZANIA**	**RWANDA**
Gen (Fixed)	4.50	9.0	n/a	n/a
Fuel Oil	6.50	Subsidized	n/a	n/a
T&D	5.0	6.0	n/a	n/a
Total Financial Tariff	**16.0**	**15.0**	**12.0**	**22.0**
Direct or Indirect Subsidy	2.0	10.0	2.0	1.0
Economic Cost of Load Shedding	0.0	0.0	8.0	0.0
Total Econ Cost	**18.0**	**25.0**	**22.0**	**23.0**