

The Role of Alternative Energy Sources in Power Systems and Water Management

Environmental Merit

- For today's environmentally sensitive society, the role of an alternative energy resource is seen to be the displacement of fossil fuel generation as a means of reducing green house gas emissions.

Power System Merits

- To a power system generation planner, three other traits must also be considered; namely,
 - scale of the resource
 - economic merit, and
 - reliability

Scale of the Resource

- Scale has two aspects:
 - Ability to meet forecast needs
 - 4 to 6 year “bite” on growth required:
 - too many small projects intractable for management
 - too large scale is uneconomic (LPWC)
 - Size of system required to concentrate required energy
 - alternative resources of low intensity
 - requires large and/or expensive and/or impractical collection systems

Scale of the Resource - 1

Alternative Energy Resources Required to Supply 8500 GW·h/yr to the National Grid

Energy Resource	Requirement
Solar	3.6 km ² of collector plates
Wind	650 km ² wind farm/3235 wind mills
Biomass (Ethanol)	4350 km ² of corn (maize)
Mini Hydropower	6000 sites

Sources:

Solar: Personal communication on actual experience with EXXON's Universe of Energy Pavilion PV installation since 1985; Reedy Creek Energy Management (Paul Allen), Disney Land, Orlando, FL, USA.

Wind: "National Electrification Planning Study: Appendixes Volume 2", Ministry of Fuel and Power, Republic of Ghana, March 1991, and "Ghana has capacity for wind power generation", Business Page, Daily Graphic, 02/02/00.

Biomass: Commercial Alcohol Inc. Plant (stated output of 300 000 000 L/yr of ethanol from 52 609 ha of corn at 7.3 tonnes/ha; yield in Ghana assumed to be 1.75 tonnes/ha), Ontario, Canada, 1999.

Mini Hydro: P "National Electrification Planning Study: Appendixes Volume 2", Ministry of Fuel and Power, Republic of Ghana, March 1991.

Economic Merit

- At present energy prices, alternative energy sources have difficulty competing in economic terms: e.g. solar energy to supply a remote village in Sudan
 - usable annual radiation on tilted surface = 5.9 kW.h/m²/day
 - 275 kW.h/capita/day requires collector area of 0.25m²/capita (ignoring losses)
 - At cost of US\$5.50 per watt of peak power output, energy cost = US\$0.377/kW.h (for the solar array only)

Reliability

- Alternative energy resources are intrinsically unreliable: e.g.
 - the sun doesn't shine at night
 - the wind only blows between 20% and 35% of the time
 - run-of-river hydro and biomass are seasonal and year over year yield is variable
- That is, alternative energy resources provide neither firm energy nor dependable capacity

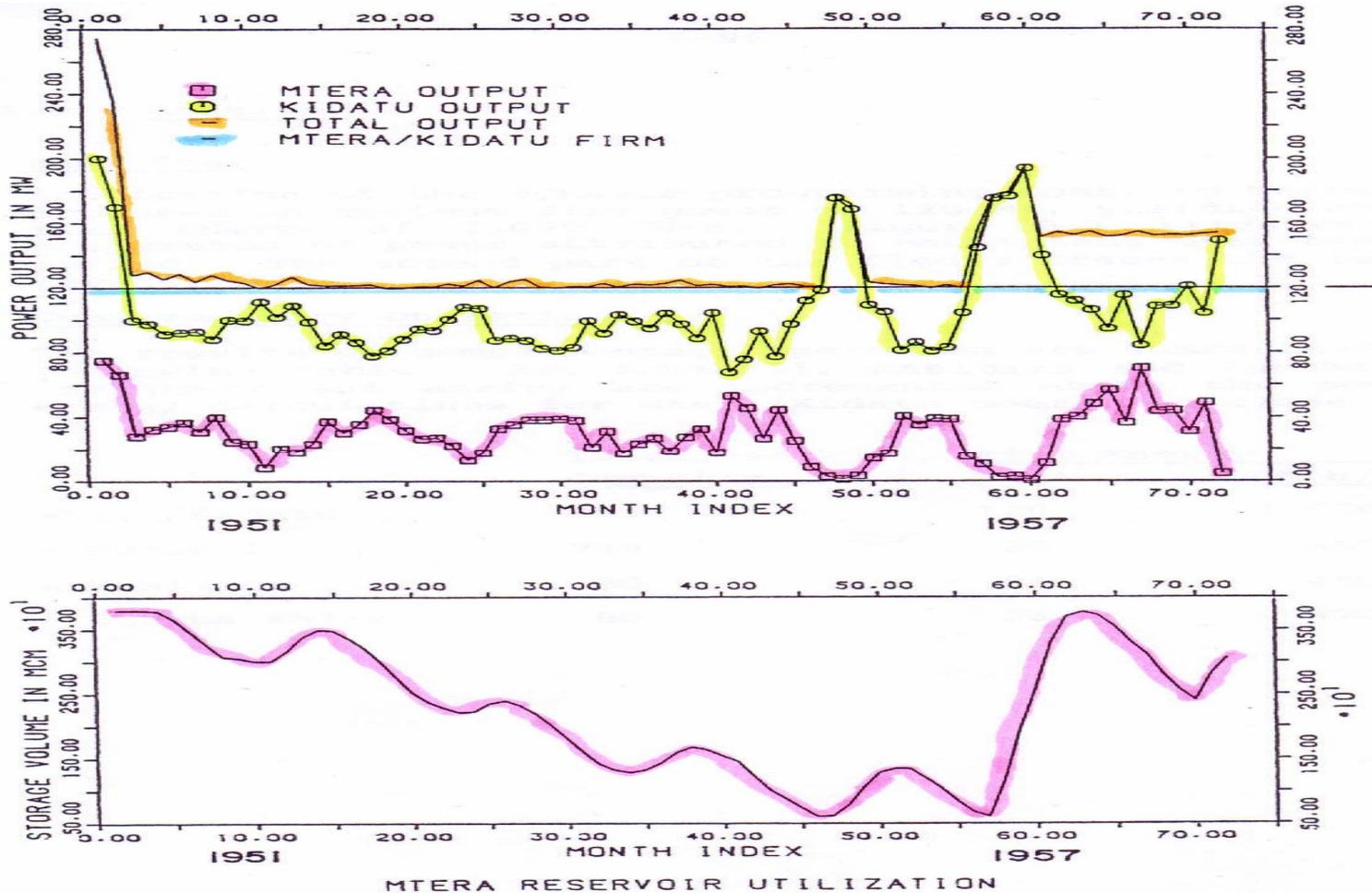
Reliability - 1

- Never the less, in the context of a power system, the energy can be made to appear firm by use of complementary thermal and/or regulated hydroelectric
- Complementary hydro generation is particularly good in this regard, provided that the concept is properly applied and the hydro resource is properly managed

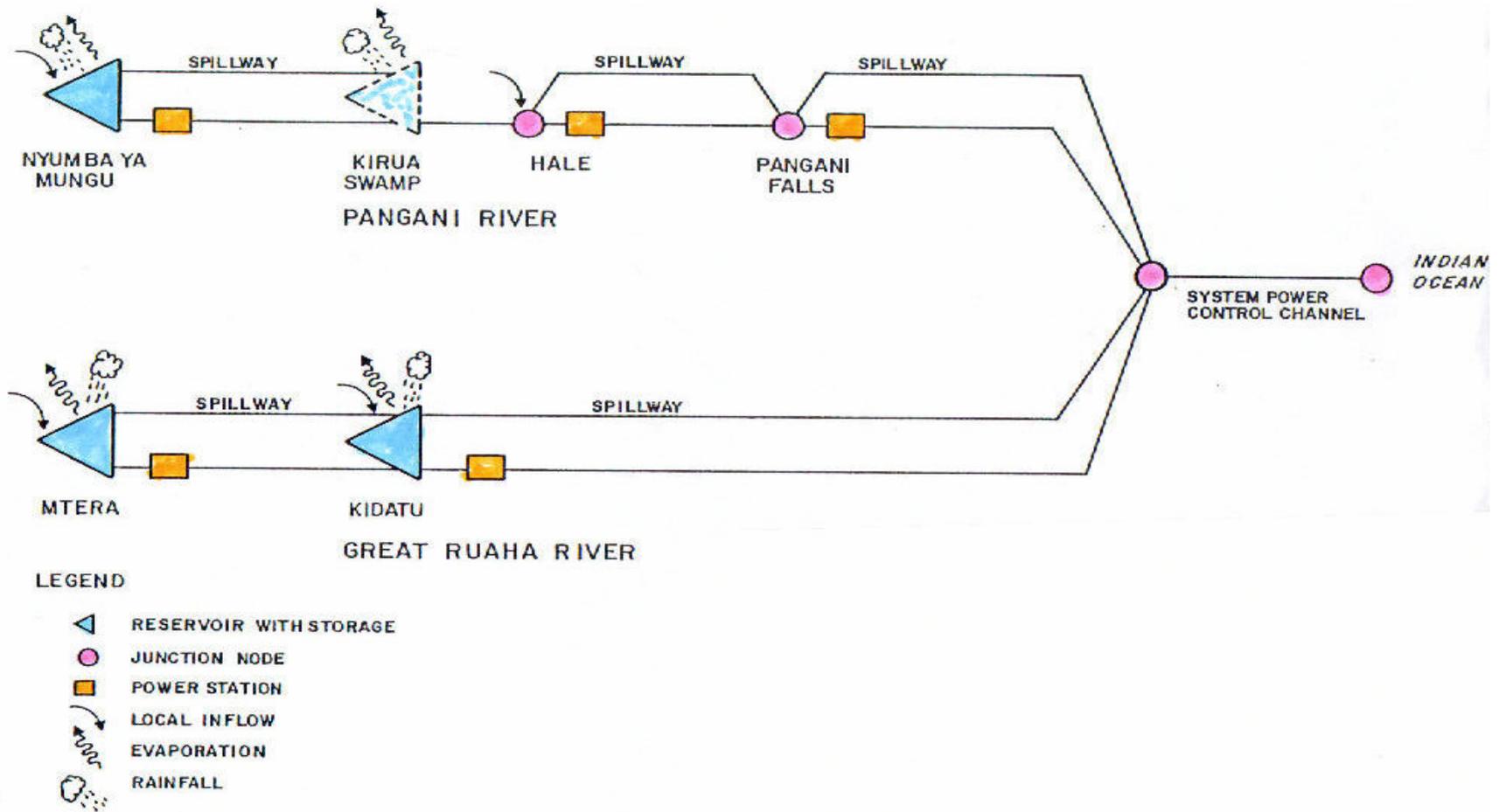
Water Management

- Concept of complementary operation
- Hydro resource energy yield characteristics

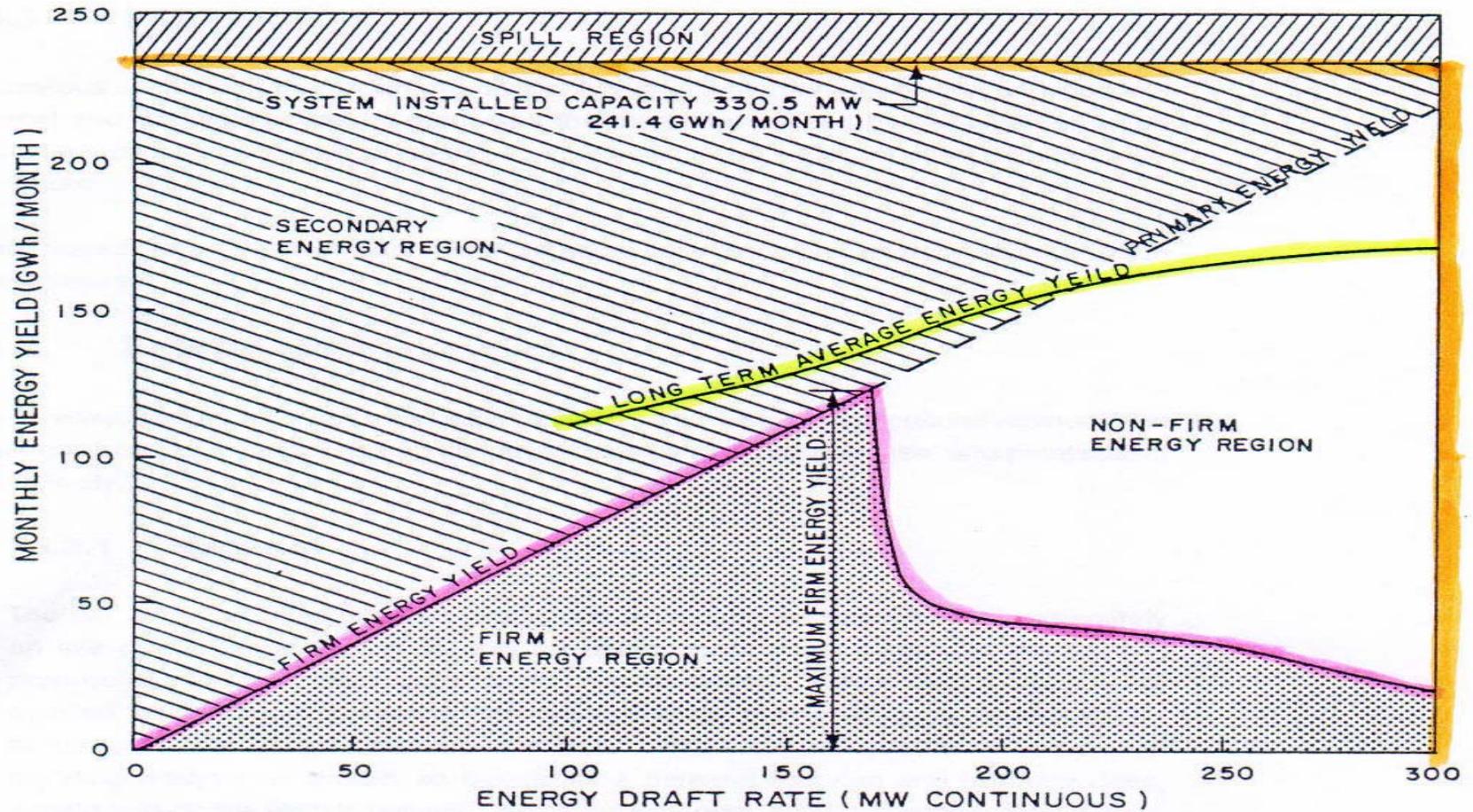
Complementary Operation of Hydro & Alternative Energy Resources



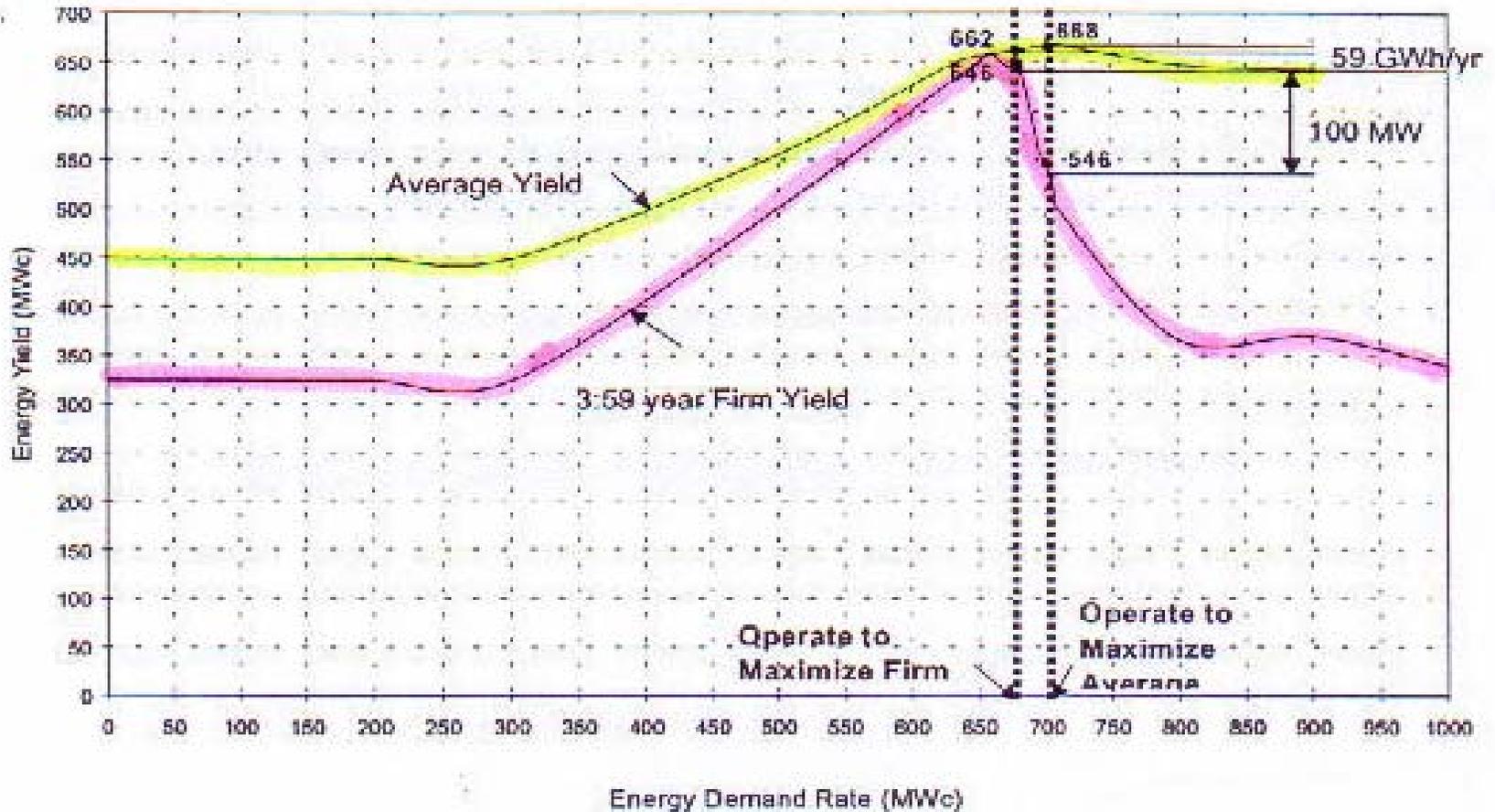
Energy Yield Diagrams for Hydro Systems -1: System Schematic



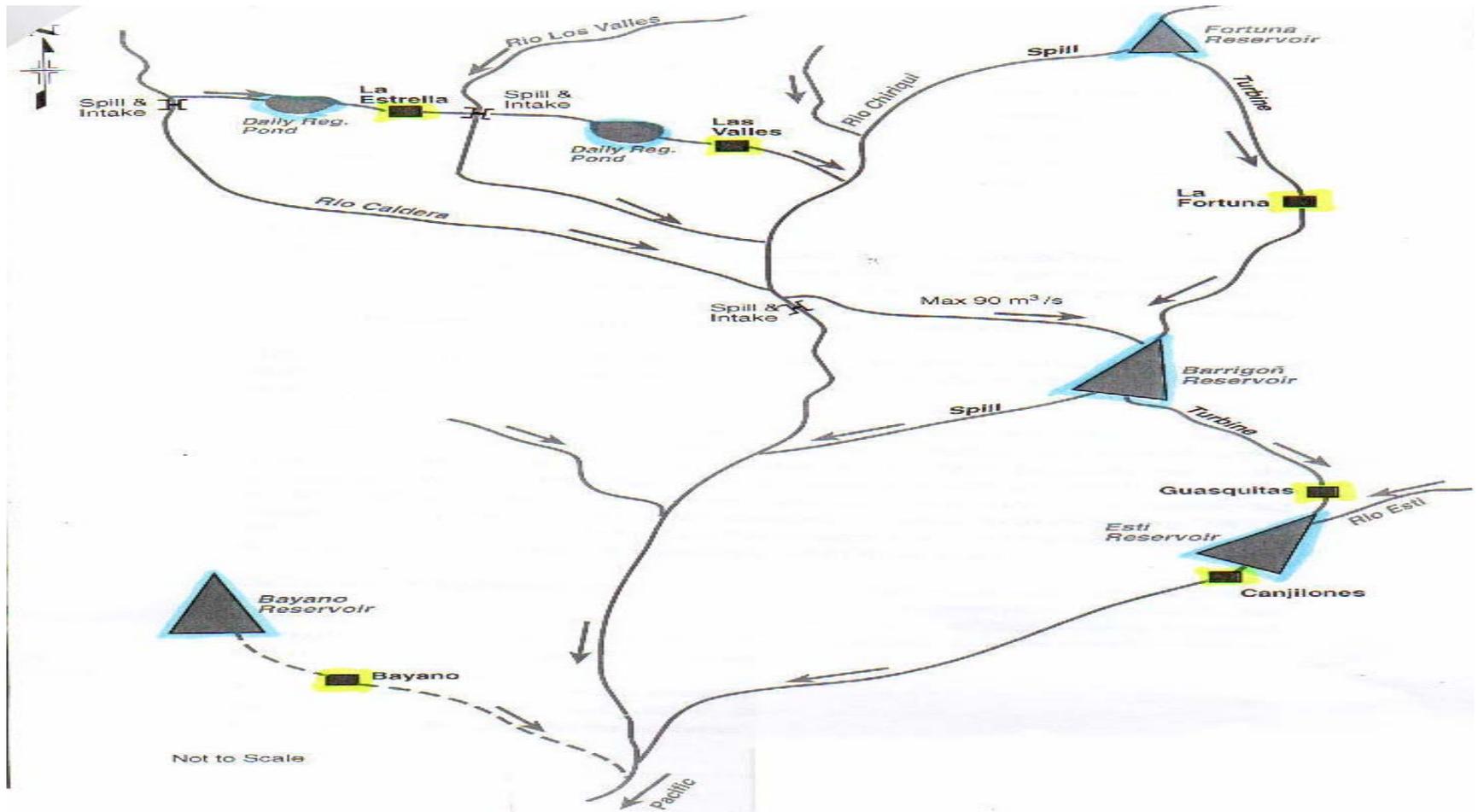
Energy Yield Diagrams for Hydro Systems -1



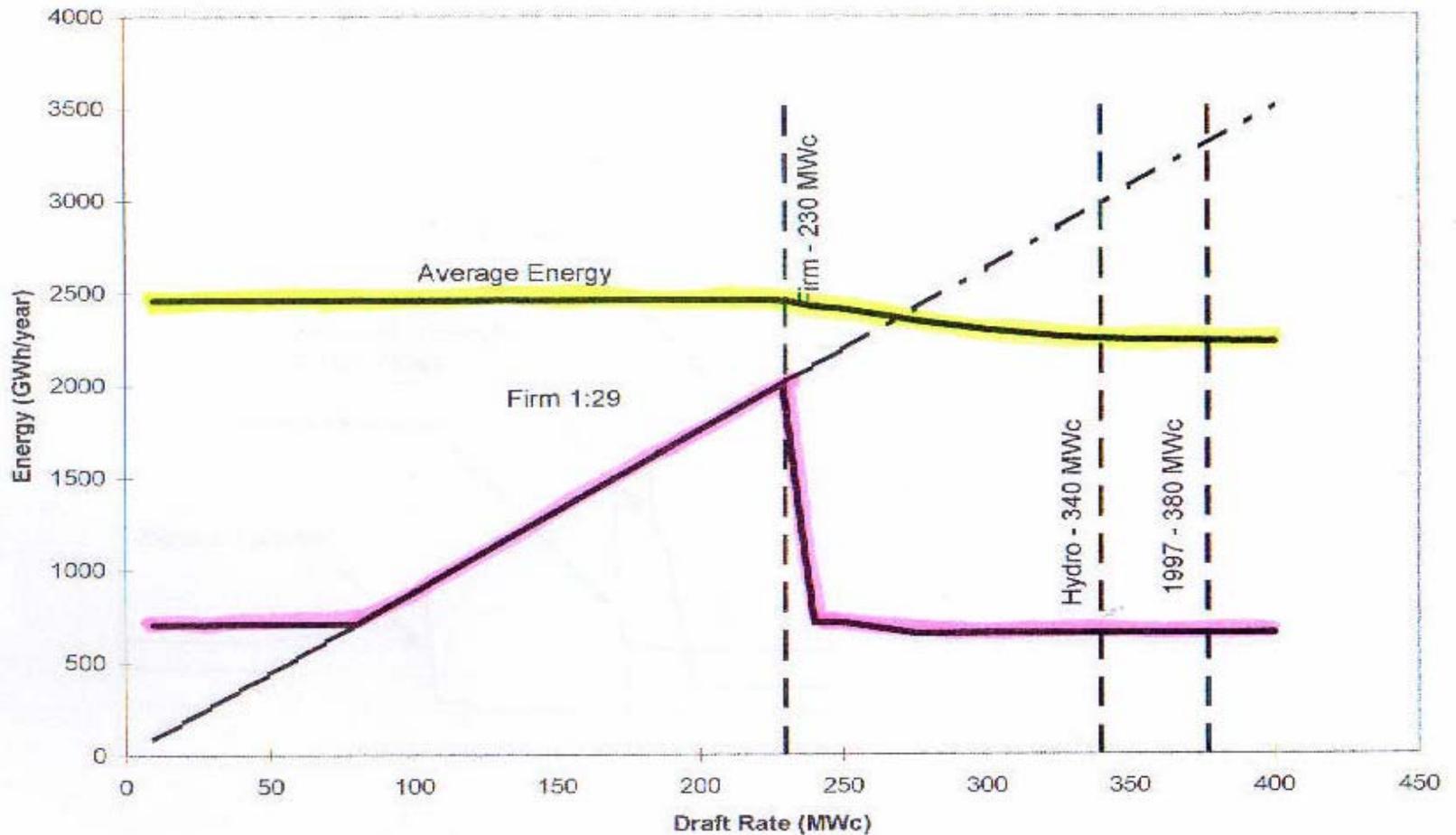
Energy Yield Diagrams for Hydro Systems -2



Energy Yield Diagrams for Hydro Systems -3: System Schematic



Energy Yield Diagrams for Hydro Systems -3



Conclusion

- The principal role of alternative energy resources is the mitigation of global warming
- Alternative energy resources have serious short-comings as providers of energy and capacity to a power system
- These short-comings can in some measure, be mitigated with intelligent operation within a large power system