Egypt's Potential for Nuclear Energy

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Nuclear Energy - IAEA

- Nuclear power is defined as the controlled use of nuclear chain reactions to free energy for the generation of electricity using U-235 (0.711% of Uranium Atom).
- Based on a International Atomic Energy Agency (IAEA) study in 2007, nuclear power generation provides 7 per cent of the world's total energy supply (thermal equivalence) and 15.7% of the world's electricity supply.
- The United States produces the most nuclear energy in quantity terms (20% of world nuclear supply) whereas France produces the highest share of nuclear supply per total domestic electrical energy demand (80%).

Egypt and Nuclear Energy

- Egypt is now at an early planning stage to undertake nuclear energy technology for electricity generation.
- In a recent study by the World Nuclear Association, it is reported that Egypt produces 92 billion kWh/yr from 18 GWe of plant, giving per capita electricity consumption of 1350 kWh/yr from thermal sources.
- Natural gas (84%) and Aswan High Dam (16%).
- Expected electricity demand growth is expected to be between 4 to 5 per cent per annum until 2050.

Egypt's Nuclear History

- The government's Nuclear Power Plants Authority (NPPA) was established in 1976.
- In 1983 the *Dabaa* site on the Mediterranean coast was selected for a nuclear power plant. This plan was aborted following the Chernobyl accident in 1987.
- A new agreement on peaceful uses of atomic energy was signed at the end of 2004 with the International Atomic Energy Authority (IAEE) as a legal document .

Egypt's Nuclear History – contd.

- Egypt already has a 1961-vintage 2 MW Russian research reactor and a 22 MW Argentinean research reactor at *Inshas* in the Nile delta which started up in 1997.
- Both are experimental pilot programs and carry outdated technologies.
- By 2006, a nuclear cooperation agreement was reached with China, and in early 2008 another nuclear agreement was reached with Russia concerning technical cooperation for nuclear power use.
- In addition, the United States, United Kingdom, and France have shown keen interest in cooperating with Egypt regarding its potential use of nuclear energy.

Nuclear Power Generation

- Techno-economic assessment is needed for the use of nuclear power generation.
- Reference documents:
  - International Atomic Energy Agency (IAEA), Egypt's Nuclear Profile, 2007.
  - International Association for Energy Economics (IAEE), *Nuclear Power Generation*, September 2007.
  - World Nuclear Association, *The New Economics of Nuclear Energy*, December 2005.
  - Massachusetts Institute of Technology (MIT), Nuclear Energy Experts Committee, Program on Science, Technology, and Public Policy, *The Future of Nuclear Power*, 2003.

Egypt's Electricity Demand

- Total electricity demand (consumption) has shown a 4.16 per cent incremental growth rate (100% impact).
- Elasticity measures for electricity consumption with respect to price, income, and GDP, yield elasticity values of 0.37 (inelastic), 1.23 (elastic), and 0.93 (neutral) respectively.
- Population growth (*H*) contributes 0.80 per cent (19.2% impact rate).
- GDP real production index (*P*) contributes 1.49 per cent (35.8% impact rate).
- Income (*I*) contributes 1.57 per cent (37.7% impact rate).
- Productivity increases (*R*) contribute 0.3 per cent (7.2% impact rate).

Figure 1: Impact Diagrams for Egypt's Electricity Consumption

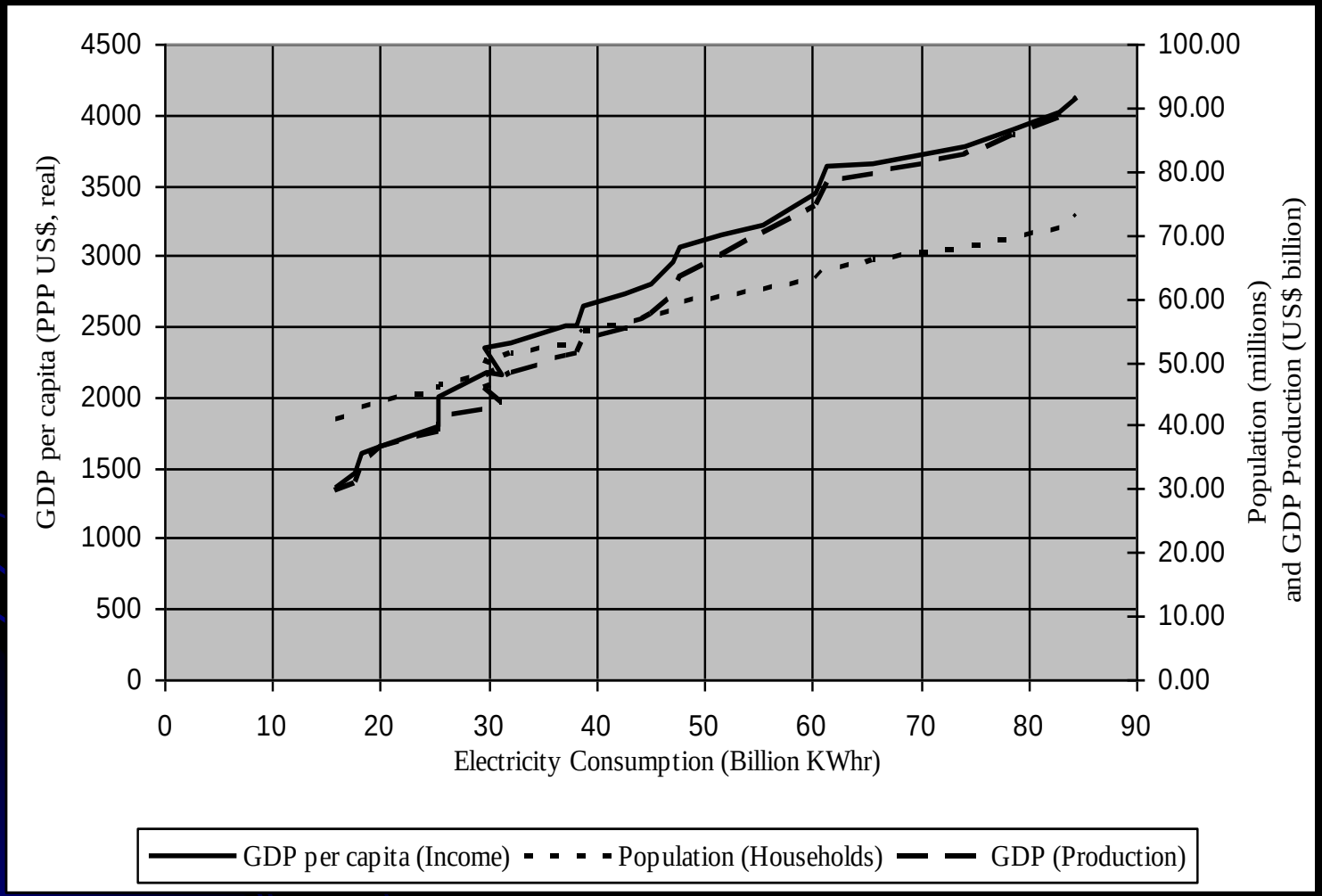


Figure 2: Trend of Egypt's Electricity Consumption and Contribution Shares

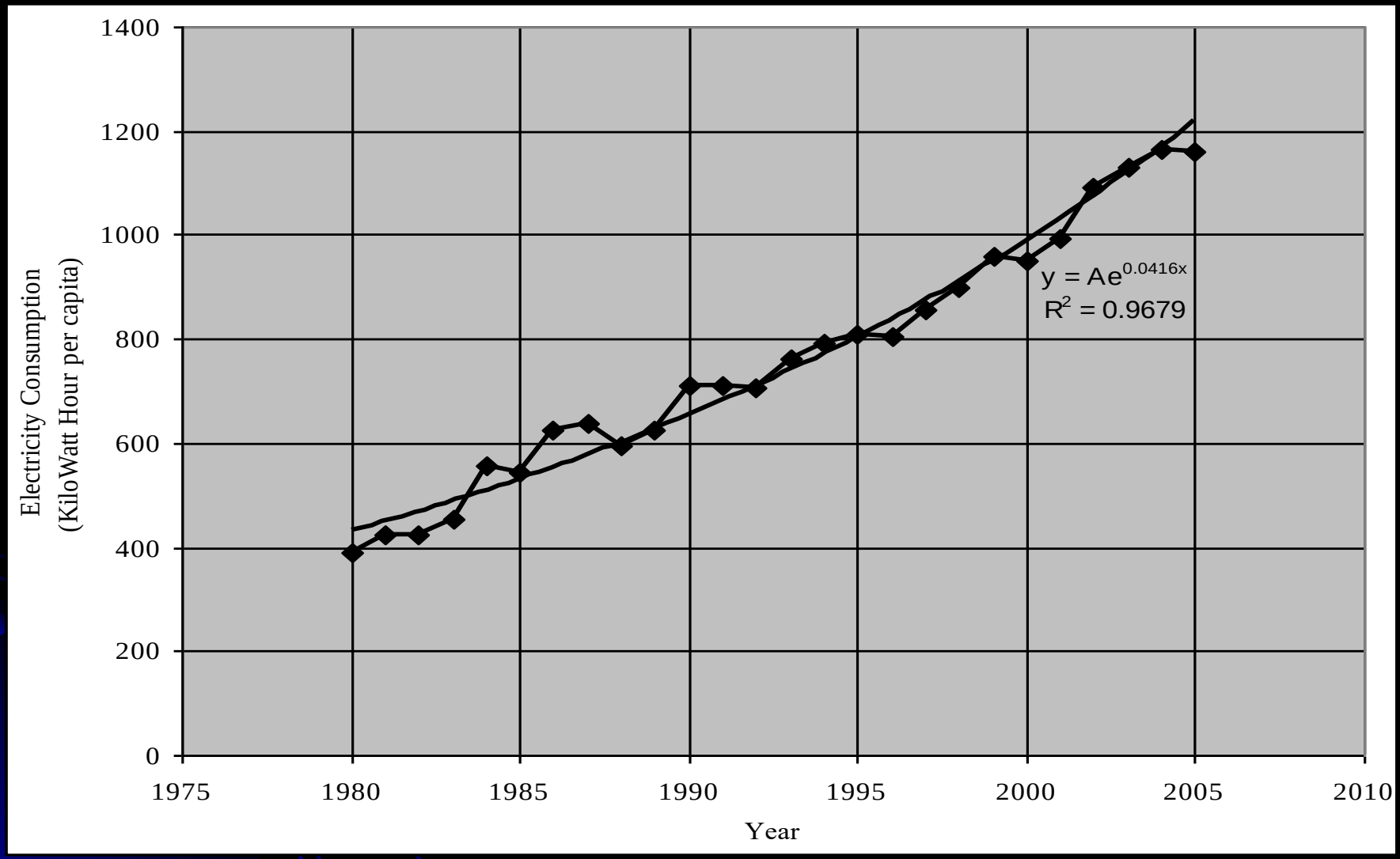


Figure 3: Egypt's Electricity Generation and Total Installed Capacity

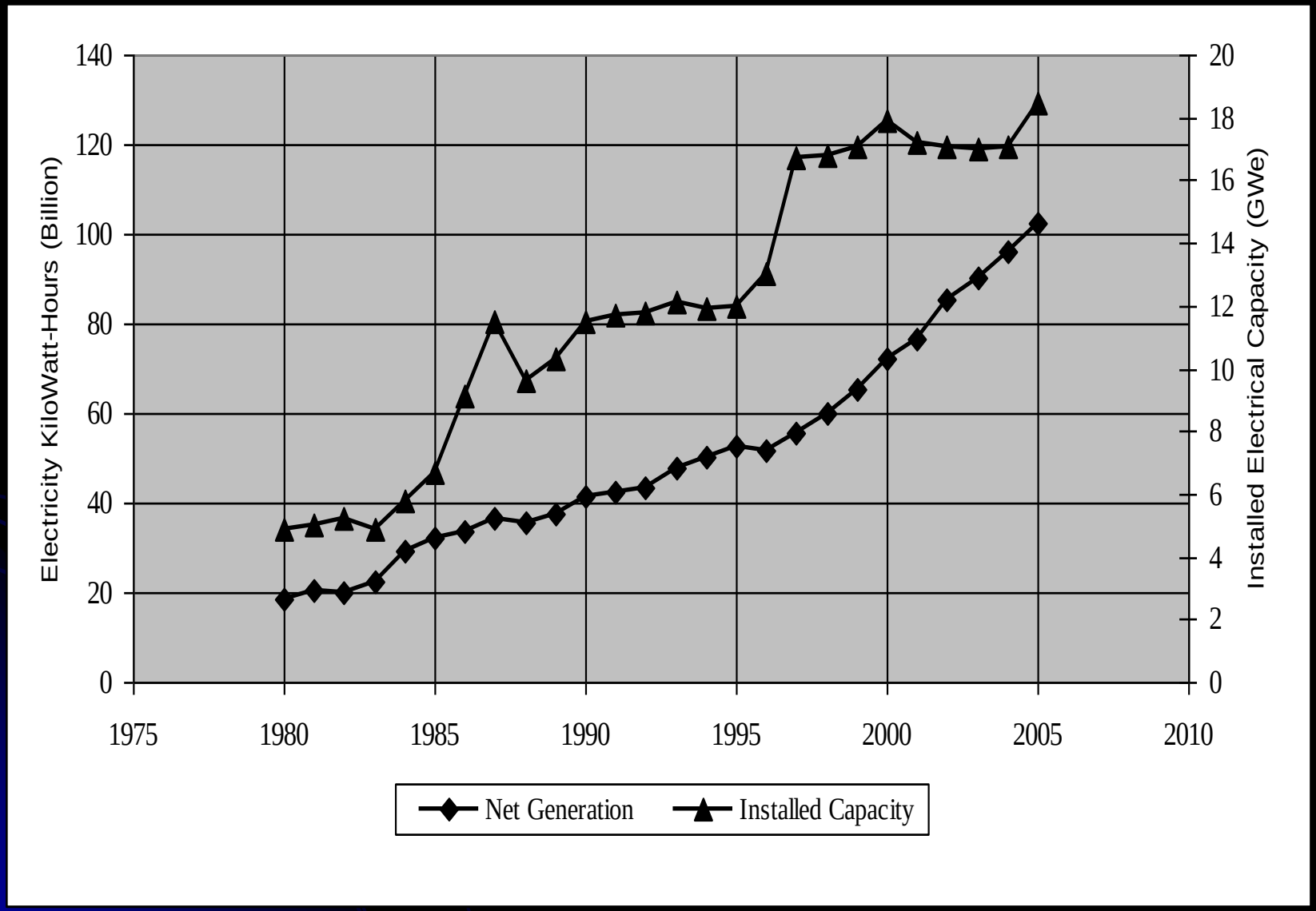


Figure 4: Target Demand and Target Supply Balance for Egypt's Electricity Sector

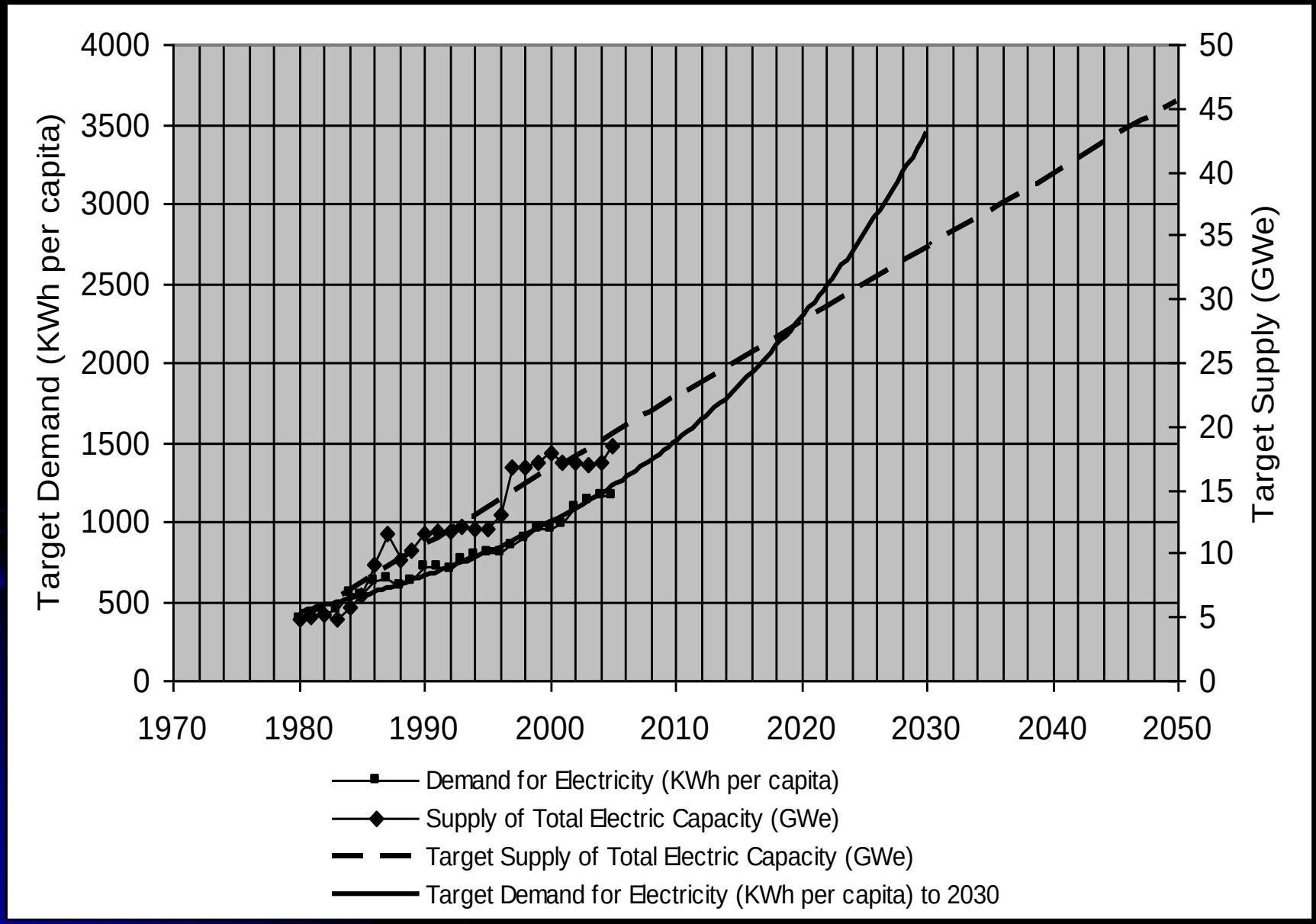
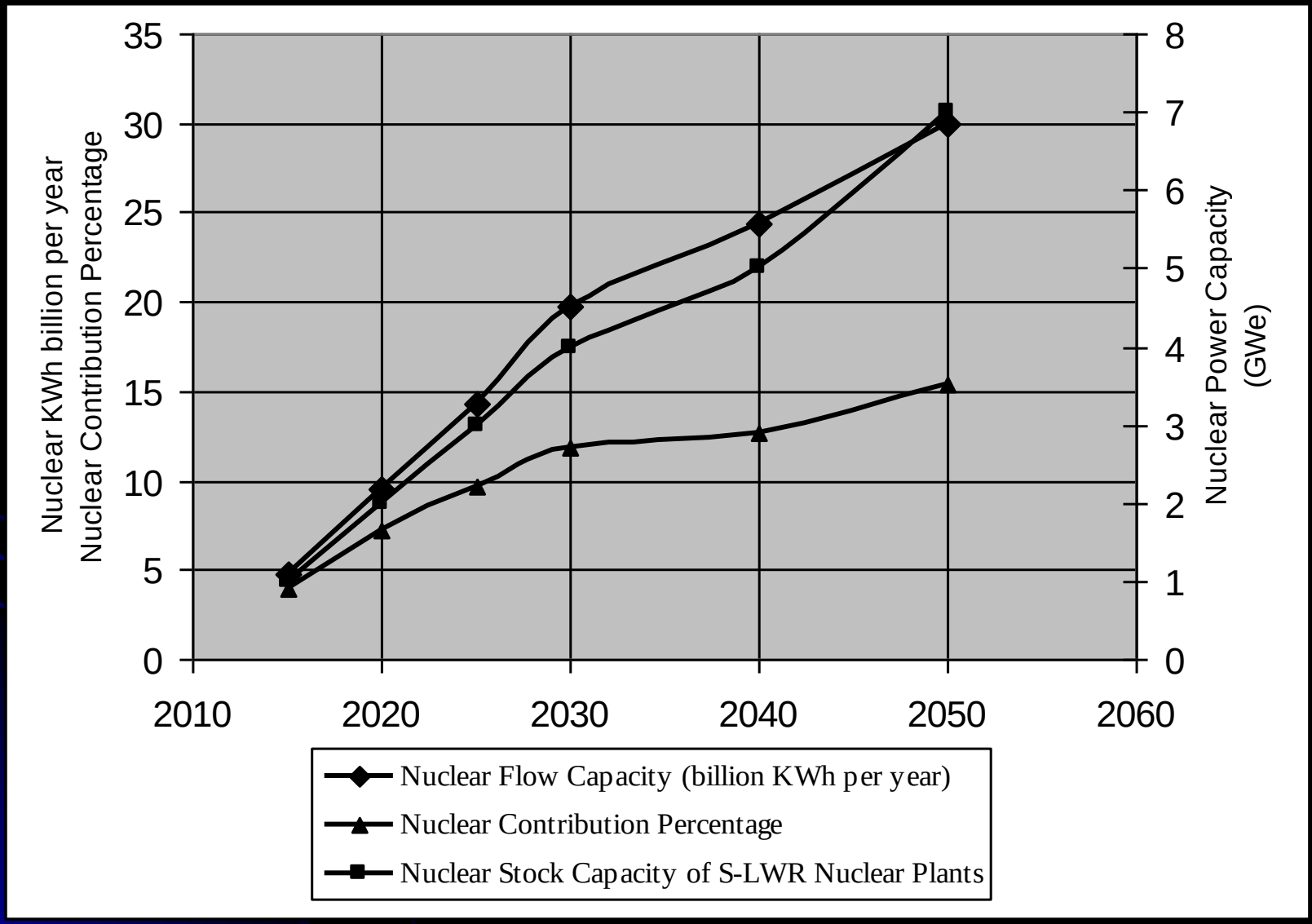
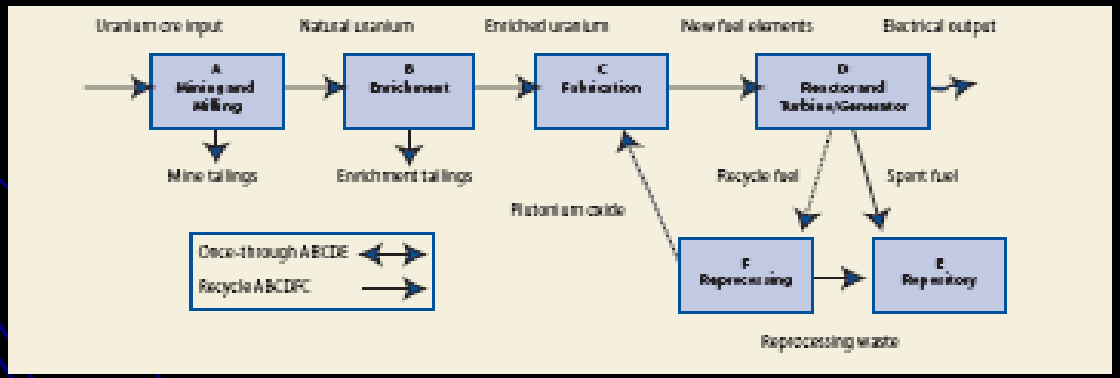


Figure 5: Egypt's Nuclear Capacity Requirements (2010-2050)



Nuclear Reactor Cycle OS-LWR (Open Slow Light Water Reactor with U-235 0.711% and U-238 Separation)



Nuclear Energy Potential for Egypt (2010-2050)

Year	*Forecasted Electricity Consumption (kWh per capita)*	*Required Electricity Supply (GWe)*	*Estimated Nuclear Energy Usage*	*Target Nuclear Production (kWh billion)*	*Number of Nuclear Plants*	*Estimated Future Capital Cost of Nuclear Power*	*Estimated Operating Cost of Nuclear Power (2008 US$ millions)*	*Estimated Uranium Fuel Cost Requirement (2008 US$ millions)*
2010	1500	22.0	0 GWe (0%)	-	None	-	-	-
2015	1839	24.9	1 GWe (4.0%)	4.8	1	$2 billion	$125.5	$18.8
2020	2255	27.8	2 GWe (7.2%)	9.5	2	$2.7 billion	$177.2	$30.5
2025	2764	30.8	3 GWe (9.7%)	14.3	3	$3.8 billion	$190.1	$36.7
2030	3389	33.7	4 GWe (11.9%)	19.8	4	$5.3 billion	$187.7	$41.7
2040	5094	39.5	5 GWe (12.7%)	24.4	5	$10.5 billion	$117.6	$34.7
2050	7657	45.4	7 GWe (15.4%)	30.0	6	$25.7 billion	$73.5	$28.8

Description of Critical Parameter	*Nuclear Energy Parameter Description*	*Critical Value*	*Conditions*
Maximum Feasible Capital Cost	Nuclear Capital Cost of 1000 MWe plant	$2.682 billion (2008 US $)	Generate output of 4.86 billion KWh per year Discount rate more than 3%
Maximum Discount Rate for Nuclear Feasibility	Discount Rate (opportunity cost of capital)	13.2%	1000 MWe nuclear plant
Maximum Unit Cost of Operating Nuclear Power	Unit Cost of Nuclear Power	6.03 cents per KWh	90% nuclear plant capacity
Maximum Price of Uranium for Nuclear Feasibility	Price of Uranium	0.74 cents per KWe	U-235 content of 0.711%
Maximum Relative Efficiency of Thermal to Nuclear	Relative Efficiency	161%	Normal relative efficiency is 72%
Minimum Nuclear Operating Efficiency	Absolute Nuclear Operating Efficiency	28%	Normal efficiency is 33%
Minimum Electricity Output for Nuclear Feasibility	Nuclear Output	4.4 billion KWh per year	Expected range of 4.75-4.95 billion KWh per year for Egypt (2010-2050)
Minimum Nuclear Plant Lifetime	Nuclear Lifetime	33 years per nuclear plant	Normal lifetime is 40 years
Minimum Nuclear Stock Capacity per Plant	Nuclear S-LWR Technology Stock Capacity	905 MWe	Normal S-LWR capacity is 1000MWe

Conclusion

Egypt's potential for nuclear energy is both feasible and necessary from an economic point of view for the sustainable long run development of the country. However, *such feasibility is not universal,* but is seen to be conditional on *multiple critical factors* which act as bounded constraints on nuclear feasibility concerning planning, implementation, and lifetime operation.

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