LONG TERM ENERGY PLANNING

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1. INTRODUCTION

In this paper, energy requirements and available, resources as known today in Pakistan and expected renewable technologies have been discussed. Based on energy resources available today and future renewable sources, energy plans for the years 2018 and 2050 have been evolved. At the end of this report recommendations have been made to overcome the energy crises and a proposal has been formulated for consideration of Government of Pakistan on energy policy matters in view of global economic situation as it persists today.

2. ENERGY PROFILE OF THE WORLD

The energy requirements of men has ever been increasing. The primitive men consumed 2000 K. calories of energy daily in the form of natural foods. With the introduction of agriculture, the energy intake was doubled. The industrial revolution and development of new technologies had further increased per capita demand to 10 times during the last two centuries. Historical facts tell us that average energy requirements will continue La increase many folds in future particularly of under developed and developing countries.

3. ENERGY AND ECONOMIC GROWTH

Since energy permeates the economy, it is understood that the social and economic structure of an economy could substantially and regressively alter, by large energy use. Fig-2, presents a scatter gram of per capita energy consumption and per capita GDP of some developed and developing countries, which represents all stages of economic-growth. The rich developed nations are placed in the top right hand corner, which indicates high per capita GDP/energy consumption, where as poor developing nations are located in the bottom left hand corner, showing low per capita GDP/energy consumption.

4. PRESENT ENERGY REQUIREMENTS

The total primary energy consumption as currently estimated is around 36.1 MTOE of which two third is met by commercial energy resources, while the remaining one third of that consumption is based on noncommercial energy resources like fire wood, charcoal and cow dung. Per capita consumption of primary energy at present works out to be 0.31 MTOE. The primary and non-commercial energy of approximately 36.1 MTOE is largely based on the use of hydro-carbon and others as brought out in the following table:

TABLE

Source of commercial Energy	Primary Energy Consumption 1987 – 88 (MTOE)	Percentage Share
Gas	9.1	25.2
Oil	9.9	27.5
Coal	2.3	6.4
Hydro	3.2	8.9
Nuclear	0.1	0.4
Total Commercial	**24.7**	**66.2**

Source of Non Commercial	Primary Energy Consumption 1987 – 88 (MTOE)	Percentage Share
Fuel Wood	6.2	17.1
Bio Gas	5.3	14.7
Total Non Commercial	**11.5**	**31.8**

Gross Total	**36.2**	**100.00**

5. FUEL POSITION

5.1 World Fossil Fuel Reserves Position

5.1.1 Worldwise reserves positions of the fossil fuels is shown in the following table:

Fuel	Reserves (R)	Consumption (C) Per year	R/C
Oil	700 BB	19.4 BB	35
Gas	3400 T.Cuft	59.Cuft	57
Coal	986 B.Ton	4.8 B.Ton	209

5.2 Fossil Full Reserves in Pakistan

5.2.1 Coal

At a consumption growth rate of yearly consumption of 2.3 MTOE coal in 1988 will be compounded to 20.13 MTOE in year 2018. The present reserves of coal are estimated at 172MTOE. The indigenous reserves of coal will tie depleted by the year 2015 (Annexure-I).

5.2.2 Gas

The total reserves of gas presently available are 18.0 billion cubic feet (41 MTOE) from Sui, Uch, Pirkoh, Mari and Khairpur fields. Present rate of growth in consumption is 4%. At this consumption growth rate, the consumption from 9.1 MTOE will be compounded to 29.5 MTOE in the year 2018. This pattern of consumption will cause total depletion of gas by the year 2014 (Fig-4).

5.2.3 Oil

Present reserves of oil are 150 million US barrels (20 MTOE). Present consumption of oil is 9.9 MTOE per annum, out of which indigenous oil consumption is only 2.2 MTOE and remaining 7.7 MTOE: is imported .

5.2.4 At a consumption growth, rate of 9.5%, the consumption of 9.9 MTOE/annum of oil in the year 1988, will rise to 150 MTOE in the year 2018. It may be noted that present reserves of indigenous oil reserves of 20 MTOE will be totally depleted by the year 1991-92, after which total oil requirement will have to be met from imports. With world oil reserves also depleting, the situation will not be manageable unless other sources of energy are discovered,:

5.3 Other Options

5.3.1 With depleting fossil fuel reserves presently known, renewable energy technologies can be expected to make a growing contribution to substitute them. Providing support for research, development and demonstration for promising technologies can accelerate development in selected areas and help lay the foundation for steady growth in use of renewable energy technologies.

5.3.2 Renewable energy technologies can be split broadly into two categories:

- Traditional technologies which are already known and costs are well established.
- New technologies which have emerged or shown promise over the past two decades.

Traditional technologies include hydro electricity, fire wood, bio gas etc.

New renewable technologies are:-

- Solar Thermal or plotovoltic process for production of :electricity.
- Wind energy.
- Ocean waves energy.
- Geothermal energy.

All the above new-renewable technologies are not fully established for large commercial uses at present. Hydel, Nuclear and. non-commercial energies are the only options presently available which will be discussed first followed by new-renewable technologies.

6. TRADITIONAL RENEWABLE ENERGIES

6.1 Nuclear Energy

By the year 2018 the load demand of electricity on the modest estimates works out to 35,000 MW. Based on the concerted efforts to utilize our hydel

fossil fuels and other resources, we may be able to meet 70% of our generation requirement through these, resources thus leaving a gap of about 12,000 MW for which there is a good prospect for nuclear generation. Hence nuclear power generation has to play a very important role in balancing the energy deficits envisaged by the year 2018. Meanwhile efforts should be made to acquire technology for utilization of indigenous uranium.

Government of Pakistan has planned to install the following nuclear power stations:-

Sr. No.	Name of Power Station	Unit No.	Capacity
1.	Chashma	1,2 & 3	2700MW
2.	South (Karachi)	1,2 & 3	2700MW
		Total	**5400MW**

The expansion of the above programmes will have to be followed until some other energy substitute are developed.

6.2 Hydroelectric Potential

Pakistan's hydro potential is estimated at about 35,000MW. Several other sites are being investigated and it is expected that another 5,000MW potential would be available in due course. This makes a total hydro potential of 40,000MW. Of this, only 3100MW has been developed and another 23,060MW is expected to be exploited by the year 2030 as shown below:

Scheme	Ultimate Installed Capacity	Amount Energy Output
Tarbela	1750MW	3.9 MTOE
Mangla	1000MW	
Others	350MW	
Tarbela Phase-II	1700NW	2.1 MTOE
Kalabagh	3600MW	4.5 MTOE
Dasu	5500 MW	6.88 MTOE
Bunji Stage-I	1300 MW	1.625 MTOE
High Thakot	2400 MW	3.00 MTOE
Bunji Stage-II	1600MW	3.38 MTOE
HighThakot	2700MW	3.38 MTOE
Small Hydels	1600MW	2.00 MTOE
TOTAL	**26160MW**	**35.015 MTOE**

6.3 Fire Wood

Pakistan is presently consuming about B MTOE of firewood, cow dung, bagasse etc. This is expected to rise to 50 MTOE by year 2010. In older to meet this demand, it is essential is a that forests be replenished. Hence there is dire necessity of extensive afforestation, fast growing trees that thrive in that particular climate should be chosen. Trees should he planted along canals for utilization of seepage losses, on hill slopes receiving more than 500mm annual rainfall and in riverine areas.

6.4 The afforestation programme be organized on scientific and commercial lines. Farmers should be given all possible help by the Agricultural Development and by WAPDA's Watershed Management Organization.

6.5 Biogas

6.5.1 There are about 3000 biogas plants operating in Pakistan. This figure is. low considering the fact that Pakistan has about 48,000 villages and only 16,000 are electrified, many more biogas plants should be installed to utilize indigenous source of energy. This will result in saving of electrical energy and large sums of money spent on rural electrification.

6.5.2 Development .of live stock at village level on scientific lines is of importance for getting amongst other things, sufficient quantity of cow dung for the generation of bio - gas for domestic cooking and for running water pumps for village water supply in far flung areas. Research and Development in this field is being carried out by ATDO, PCSIR, University of Engineering Technology, Peshawar, Lahore and Director General of Energy Resources. This research must, be intensified.

6.5.3 As there are a number of poultry farms in the country, technology rerating to biogas plants bas rid on poultry droppings needs to be streamlined and standardized to further enhance generation of energy through indigenous resources.

7 New Renewable Energies

7.1 Solar Energy:

Pakistan is rich in solar energy. Solar energy is clean, renewable, abundant and ,widely distributed. Solar energy can be directly used through reflectors and deflectors and is also convertible into mechanical and electrical energy with reasonable efficiency. It is thus a unique source of energy which tan and has been used successfully to meet domestic needs for lighting, water heating, space heating, cooling, agriculture pumping, crop drying and cold storage. Broadly speaking solar energy can be divided into two categories:

a. Solar Thermal.

b. Solar Photovoltaic Power.

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a. Solar Thermal

i) Currently some 300,000 solar energy water heaters are sold annually in the world.

ii) In Europe and Australia passive solar houses are now being marketed by an increasing number of builders.

iii) Water pumps for agriculture and swimming pool heaters are also getting popular day by day.

b. Solar Photovoltaic Power

The development of solar cell which converts light has opened new avenues of its into electricity utilization, as the electricity has unlimited applications in all the productive and non productive sectors. The problems at present are high costs compared to energy from conventional sources and large space requirement for its installation. At the present researchers are working to reduce the cost of energy produced and space requirement. It is predicted that silicon solar cell cost will follow the same behaviour as of silicon transistors. The cost of energy produced and capital cost, will be at par with the energy produced from the conventional sources within the next two decades. The leaning behaviour of the solar cell i.e, .an average reduction of 23% on every doubling of the cumulative production is indicated in Fig-6. Projected cost figures for photovoltiac system with production ranging from 1MW. in 1982 to 10,000MW in 21st century are as under:-

Production	**1MW**	**10MW**	**100MW**	**1000MW**	**10,000MW**
Cost/Peak Watt US$	12	4	1.5	0.5	0.3

The present cost of fossil fuel energy generation is estimated at U.S$1.0 per peak watt. Adding 50% transmission and distribution charges, the total cost at consumer end comes to US$ 1.5 per peak watt. Taking 5% inflation rate, it is expected that breakeven point for solar cell cost may be achieved by the year 2005 (see Fig-6). The mass production as a consequence of demand, will further reduce its price, making it a cheaper source of energy by the year 2010.

We are receiving radiations capable of producing 2200 to 2500KW hrs/annum/m2 area of solar cell with an array efficiency of 10%, we can have a solar dam, capable of producing 56 billion KW/Hrs of electrical energy per annum over an area equivalent to Tarbela lake (256 sq km).

Pakistan has already developed a practical strategy to develop both solar thermal and photovoltaic system. The solar thermal is developed for water heating and cooking and photovoltaic system for village electrification and water pumping. Fifteen villages with power requirement from 10-60KW; have already been electrified. Pakistan is one of the countries which is favourably placed for taking maximum advantage of this technology. The following are the areas where we need to pay attention:-

i. A large number of villages, over 40,000, still remain to be electrified. A significant portion of these lie in remote and isolated areas, such as mountains and deserts where population is widely scattered. It is difficult and expensive to supply electricity to such areas in the conventional manner.

ii. A large number of farmers have small agriculture holdings, where irrigation through photovoltaic pumping can he more economical.

iii. Remote and rural area telecommunication ,programmes can be embarked upon with photovoltaic power supply system.

7.2 Hydrogen:.

Hydrogen is plentiful in the form of water. It is the cheapest synthetic fuel to manufacture per unit of energy stored in it. This fuel allows catalytic combustion at lower temperatures than combustion arising from hydro carbons, It is a unique fuel having very desirable properties. At the user end, it can be converted to various energy forms needed more efficiently than others. It is non-polluting of all the fuels. Hydrogen energy may be used in every application where fossil fuels are used. Its high flame speed and wide flammable limits, make hydrogen a very good fuel for internal combustion engines, gas turbines and jet engines. Now research has been diverted towards hydrogen energy system as a replacement for the present fossil fuels. In short with depletion of all reserves, hydrogen is likely to take its place as a transport fuel.

7.3 Geothermal:

Volcanic eruption lava flows and hot springs are indications, of the enormous energy held within the earth. Little information is available on this source of energy in Pakistan. Chitral perhaps will be best area for exploration for this purpose. It is widely distributed under the earth and the depth and temperatures are the key measures of its value. Low resources of energy are suitable for direct such as heating and high temperature sources are. suitable for electricity generation.

7.3.1. Some of the demerits of this source are, that the calorific value of this source of energy is less compared with the energy from fossil fuels and it can only be used near its origin.

7.3.2. The technology for using geothermal is well developed in some of the foreign countries and technology improvements are underway that promise lower cost and increased use of geo thermal energy.

7.4. Wind Energy:

Pakistan's best wind resources are to found at coastal locations in .Baluchistan province. In these areas, remote from electricity grids, wind turbines will offer an economically, viable option, compared with conventional power plants or extending grid system to these remote areas.

8 ASSESSMENT OF ENERGY REQUIREMENTS

8.1 For future energy policy formation and assessment of energy requirements, historical energy consumption, GDP growth rate, future energy prices, world economic conditions, new discoveries, expected outcome of experimental technologies are all factors which make this subject a complex one.

8.2 For assessment of future energy requirements. Seventh Five Year Plan has been followed wherein growth rate has been shown as 8% for the next five years. Logically one could not adopt the same growth rate till the year 2050. As requirements are compounded and base broadens, the targets based on this percentage becomes difficult to achieve. GDP growth rate of some of the developing countries such as South Korea have been studied which over the periods show a decreasing trend in percentage energy consumption. Following the same trend, we have assumed the energy growth rate as under:

Years	**Energy Requirements Percentage increase**
1987-93	8%
1993-2000	7%
2000-2010	6%
2010-2020	5%
2020-2030	4%
2030-2040	2.5%
2040-2050	2%

8.3 The total energy requirements so calculated works out to 200 MTOE for the year 2020. Out of which we can meet 27.0 MTOE from Hydel, if sources as planned by WAPDA are implemented, 70 MTOE from fossil fuels, and 25 MTOE from the non-commercial energies as wood and biogas.

8.4 Remaining gap of 78 MTOE has to be filled up from new renewable energies and nuclear (see Fig-7). If Government completes the Chashma and South Power Plants, it is expected that 5.5 MTOE will be available from nuclear and the remaining mainly from new renewable energies. Solar and Hydrogen energy may fill up this gap.

8.5 Based on the above assumption, total energy requirements for the year 2050 comes out to 475 MTOE, out of which we may meet ,35 MTOE from Hydel, 60 MTOE from fossil fuels, 40 MTOE from non commercial energies and remaining from new renewable energies.

9 ENERGY PER CAPITA AND POPULATION GROWTH

9.1 To achieve higher energy per capita consumption with the proposed energy scenario, It is essential that Government should exercise proper controls to reduce the population growth rate. The public should be educated and population growth rate cut from 3.1% to zero in steps. Earlier we achieve this target, better it will he to boost Socio-economic conditions of our country.

9.2 The population by the year 2050 with controlled growth rate as proposed, would be about 223 million against 677 million if allowed to rise at the present growth rate of 3.1% per annum. The effect of population on per capita energy consumption is indicated in the table below:

TABLE ENERGY PER CAPITA

Year	Energy Per Capita (Controlled Population Growth)	Energy Per Capita (Uncontrolled Population Growth)	Suggested Population Growth Rate
1987	310	310	3.1%
1987-93	410	407	3.0%
1993-2000	554	510	2.0%
2000-2010	802	673	2.0%
2010-2020	1080	763	1.5%
2020-2030	1443	833	1.0%
2030-2040	1753	783	0.5%
2040-2050	2153	700	0

It may be noted that at this time, energy per capita requirement of South Korea is 1600 KGOE, of UK about 4000 KGOE and of USA more than 10,000 KGOE.

10. CONSERVATION AND ENERGY EFFICIENCY

Potential exists for major improvements in conservation of energy and the efficiency with which it is used. The realization of this potential is central for achieving the Government's goals of development. Government action is warranted in bringing about improvements in use of energy efficiency with special emphasis to electric energy loss reduction programme and implement energy conservation plans as discussed in detail subsequently. Energy efficiency improvements and conservation will contribute to longer term energy supply security, will result in direct cost savings for consumers and will have a profound influence on the well-being of the economy.

10.1 Energy Loss Reduction Programme

Electric Power System in Pakistan has expanded very rapidly, therefore, it is overloaded and system losses are nearly 24%. Out of this, transmission and distribution losses are 8.45% and 13.45% respectively'. WAPDA has already commenced energy loss reduction programme for 2200 Nos 11 KV circuits, The estimated expenditure for rehabilitation of thee feeders, would be Rs.5096 millions. The programme is as detailed below:-

i. Installation of express feeders.

ii. Bifurcation of overloaded and lengthy feeders.

iii. Reconductoring of undersize' conductors of existing feeders.

iv. Replacement of overloaded transformers.

v. Extension of 11KV lines where existing long LT lines are causing low voltage problems.

vi. Installation of capacitors.

vii. Reinstallation of energy meters by shifting them from inside the premises to outside and housing them in water proof anti theft boxes, properly sealed.

viii. Checking of defective meters and their replacements.

ix. While giving new industrial connection, either the meter should be on the pole or in case of indoor substation, should be located with direct entry from outside. In any case the meter should be installed, in anti-theft box, properly sealed.

In order to bring the transmission losses within the following measures are suggested:-

i. Installation of capacitors at secondary grid station i.e, 132/11 KV & 66/11 KV grid stations.

ii. Installation of High Voltage capacitors at Transmission voltages.

iii. Construction of more 500KV/220KV & 220kV/132KV grid stations.

iv. Construction of new Transmission lines where existing transmission lines are overloaded.

v. Construction of 132KV transmission lines where existing 66KV lines are overleaded

10.2. Similar steps are also recommend for KESC System at Karachi to reduce distribution and transmission losses to reasonable limits. At present losses of KESC System are 18% (excluding Auxiliary losses).

10.1, Energy Conservation

Pakistan like many other developing nations faces a serious energy crisis. Indigenous resources of Pakistan for fossils fuels -are limited. In the modern world energy is the key to progress. Energy conservation on a national scale could save the country 12.3 MTOE equivalent by year 1993 according to an estimate of ENERCON, Pakistan. Some of the measures for conservation of energy are presented in the: following sections:-

i. Government, WAPDA and the Media i. e, Newspapers, radio and T.V should make a coordinated effort to educate general public for conservation of energy. All lights, fans and other appliances when not in use, should be switched off. Similarly, gas burners should be put off

when not in use. Defective water taps should he repaired as wastage of water means wastage of energy required to pump it.

ii. Most of lighting load is constituted of low cost incandescent lamps. If public is encouraged to use flourescent tubes and gas filled lamps instead of incandescent lamps, it is estimated that for equal human output saving of energy of 800 million units per annum is possible. A system of additional taxes and excise duty for incandescent lamps is proposed and free import of components of flourscent tubes/gas filled lamps be allowed.

iii. Measures should be adopted to save energy in public and private buildings through new methods of construction e.g, use of thermal insulation to optimise use of air -conditioning, heating and hot water production system.

iv. Minimum use of exterior glass be made for air-conditioned spaces.

v. Maximum use of natural light be made as against -artificial lights for non-airconditioned spaces.

vi. In order to improve the quality of chokes, fans, motors and other appliances using magnetic cores, the silicon steel sheets should be allowed to be imported free of duty Ordinary steel sheets be probibited to be used in these appliances through a regulation.

vii. Two part tariff be introduced for industries and agriculture to discourage use of electricity at. peak load timings and accordingly energy meters with time switches should be installed.

viii. Staggering of holidays for industries is to be implemented by coordinating with respective Chambers of Commerce and Industry.

ix. Use of big cars should be banned. Public transport viz. buses, micro buses and wagons be encouraged to minimise use of cars.

x. National Material Inspection Agency should be established to register and control electric equipment manufacturers to guarantee the production of quality equipment and appliances.

xi. Electricity tariffs should be rationalized, so as to force the consumers to conserve energy. Also incentive should be given to private sector to invest and generate power for sale to WAPDA & KESC. Similarly tariff for Suigas should also be rationalized to ensure conservation of gas on the part of consumers. High penalty for industries for maintaining low power' factor he levied through tariffs.

The population of Pakistan is now estimated about 96 million. Present rate of growth of population is 3.1% which is very much on high side. Government should educate the people to realize the need of family planning and to check the growth of population.

11. RECOMMENDATIONS

i. Because of earlier depletion of oil and gas resources, it is recommended that coal fired power stations, nuclear power stations and hydel power stations should be installed to meet the growing demand of power in domestic agriculture and industrial sectors.

ii. Measures discussed in detail in the previous chapter be implemented to conserve energy at all levels.

iii. Afforestation and livestock expansion be made as a national policy to increase non-commercial resources of energy.

iv. Measures discussed under Energy Loss Reduction be got expedited.

v. Population growth rate to be checked and brought down to 0% as early as possible.

vi. Research and development of renewable resources of energy be intensified in the following areas:-

   a. Solar Energy.

   b. Wind Mills.

   c. Tidal Waves.

   d. Geo-Thermal.

vii. Greater participation of private sector be encouraged to invest in power station installation and in exploration of oil and gas.

viii. Concerted efforts should be made to explore and discover indigenous oil reserves in Pakistan, which at present constitute 30% of country's energy need with 70% as imported oil.

12. CONCLUSIONS

12.1. After reviewing the energy resources available, present energy profile, future energy requirements and effect of energy over social and economic structure of an economy, it has become clear that there is much to be desired and implemented. Government of Pakistan has to streamline and channelize the policies for healthy growth, proper development of its economy, and improvement of industrial base, which in brief, is termed as "improvement of socio–economic conditions".

12.2. Today payment imbalance among major trading nations persists, as do the debt of many developing countries. This has severely effected the GDP growth of the developing nations. There is no viable alternative to this adjustment. Longer the Government waits to implement their development plans the harder the task will he. Countries will certainly gain from their own policy reforms which requires concerted action, it is essential that our country improves the conditions; for its own interactions with rest of the world in order to benefit from global economic conditions.

12.3 It may be noted from the estimated energy requirements (Fig.7) that with depletion of fossil fuels, Pakistan's energy situation will enter a crucial stage by the year 2005. The gap between energy demand and conventional fuel energy supply will start widening and by the year 2018 there will be gap of 78 MTOE against total energy demand of 475 MTOE (Fig.9). Compare these figures with today total demand of 29.6 MTOE only and ponder for a while. We must plan for tomorrow in a fashion not put our coming generation in a embracing position. The plans indicated for the year 2050 are not ambitious ones, hardly sufficient to raise our GDP/Capita equivalent to south Korea's today provided zero population growths rate is achieved by the year 2040. This situation will not be controllable unless Government channelizes its policies to develop long term plans spread over thirty to fifty years and then abstracts medium term plans (5 years) out of it for implementation, to be in line with the final targets.

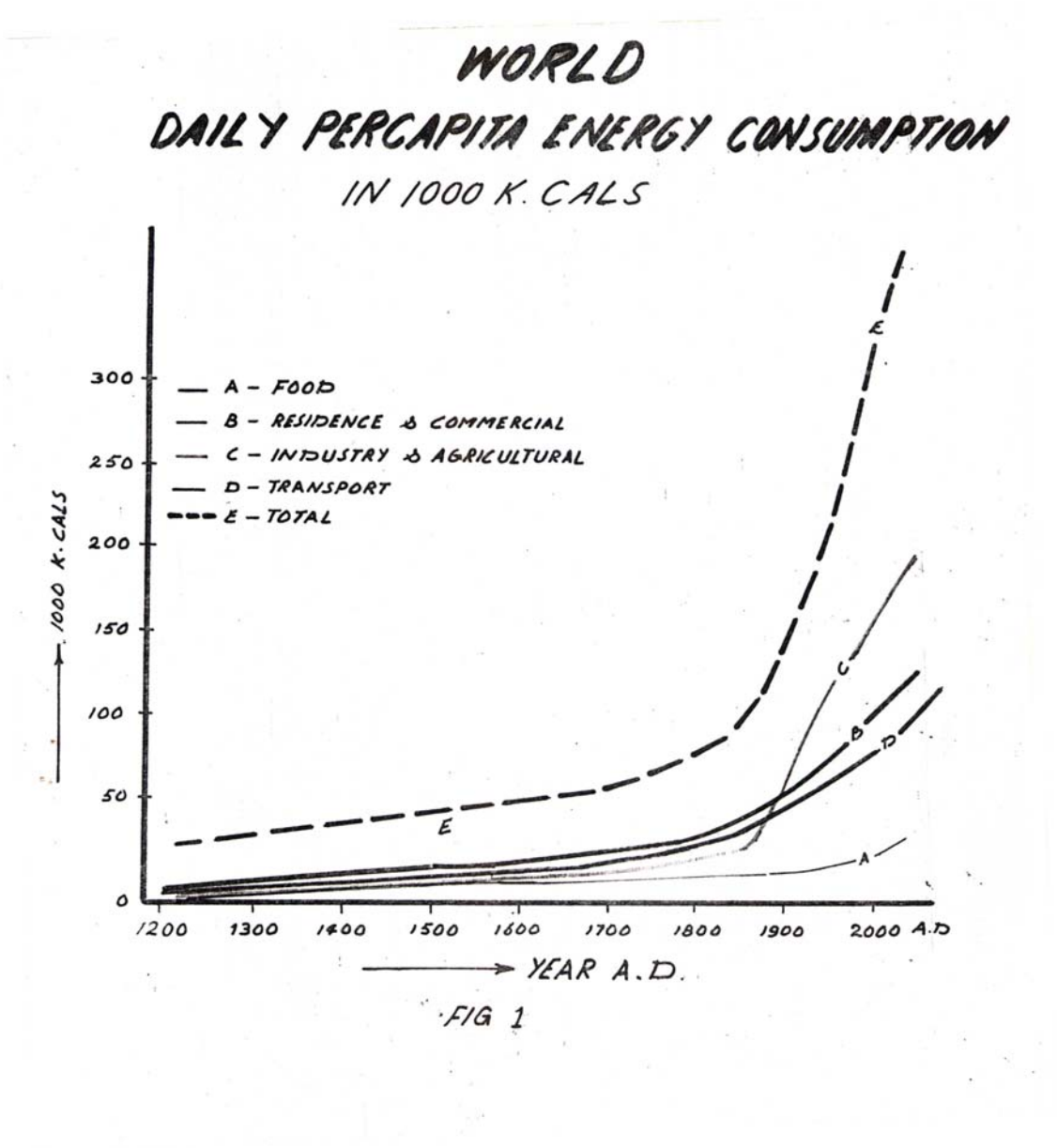

WORLD
DAILY PERCAPITA ENERGY CONSUMPTION
IN 1000 K. CALS
A - FOOD
B - RESIDENCE & COMMERCIAL
C - INDUSTRY & AGRICULTURAL
D - TRANSPORT
E - TOTAL
1000 K. CALS
300
250
200
150
100
50
0
1200
1300
1400
1500
1600
1700
1800
1900
2000 A.D
YEAR A.D.

FIG 1

ENERGY & GDP PER CAPITA

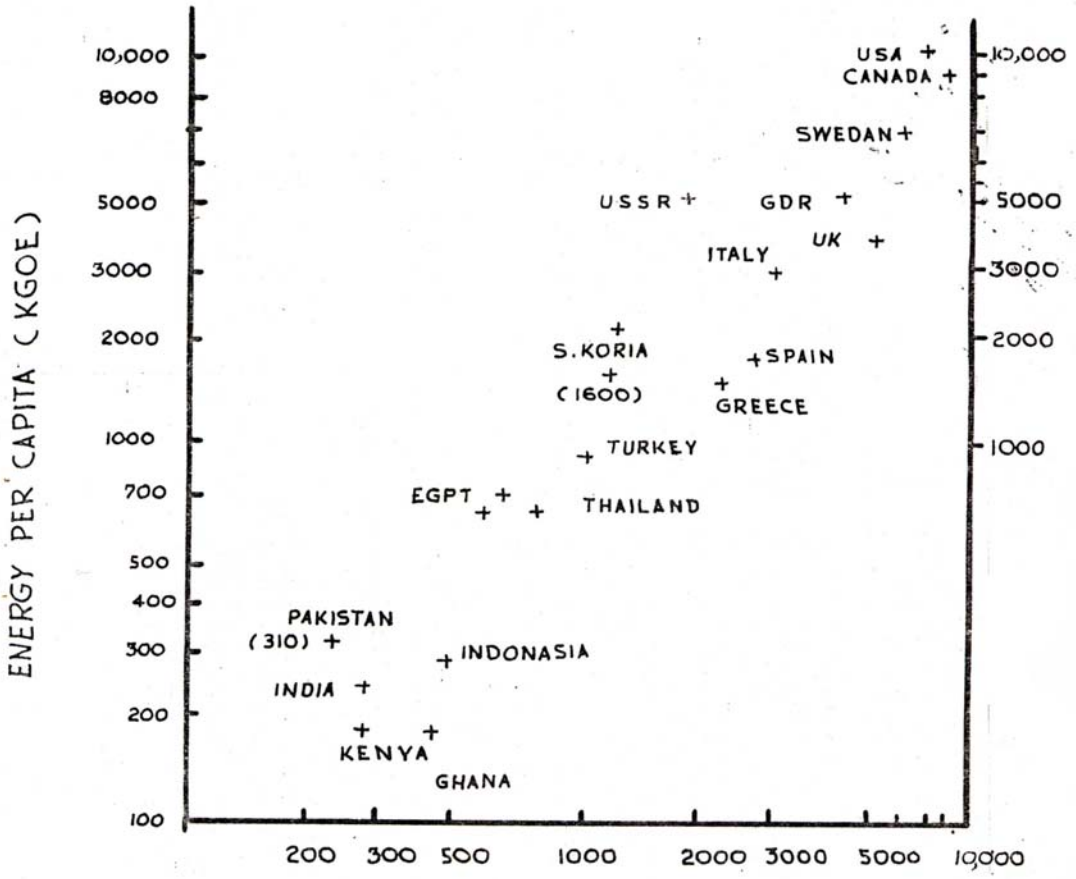


FIG 2

COAL RESERVES IN PAKISTAN

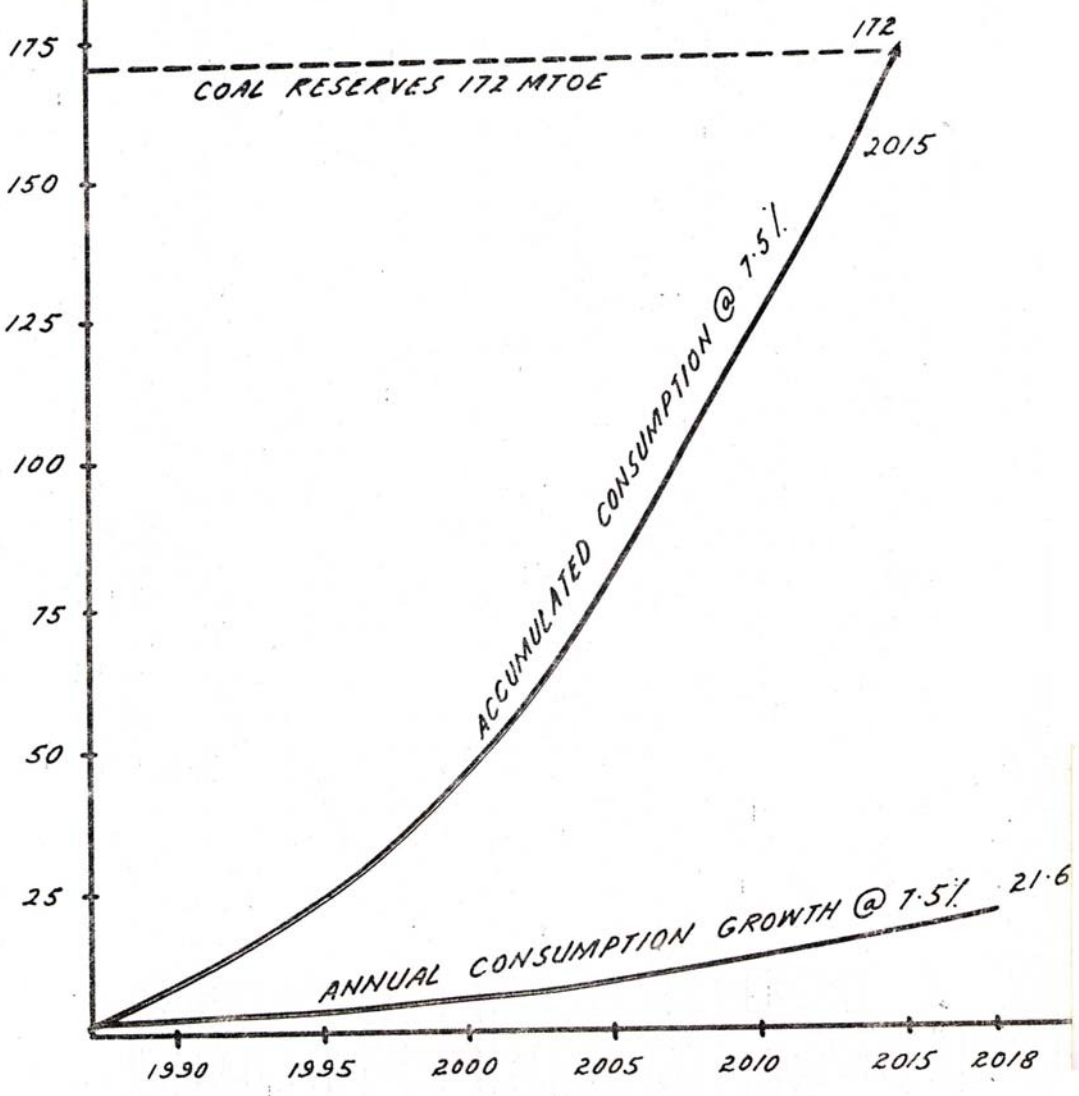


FIG 3

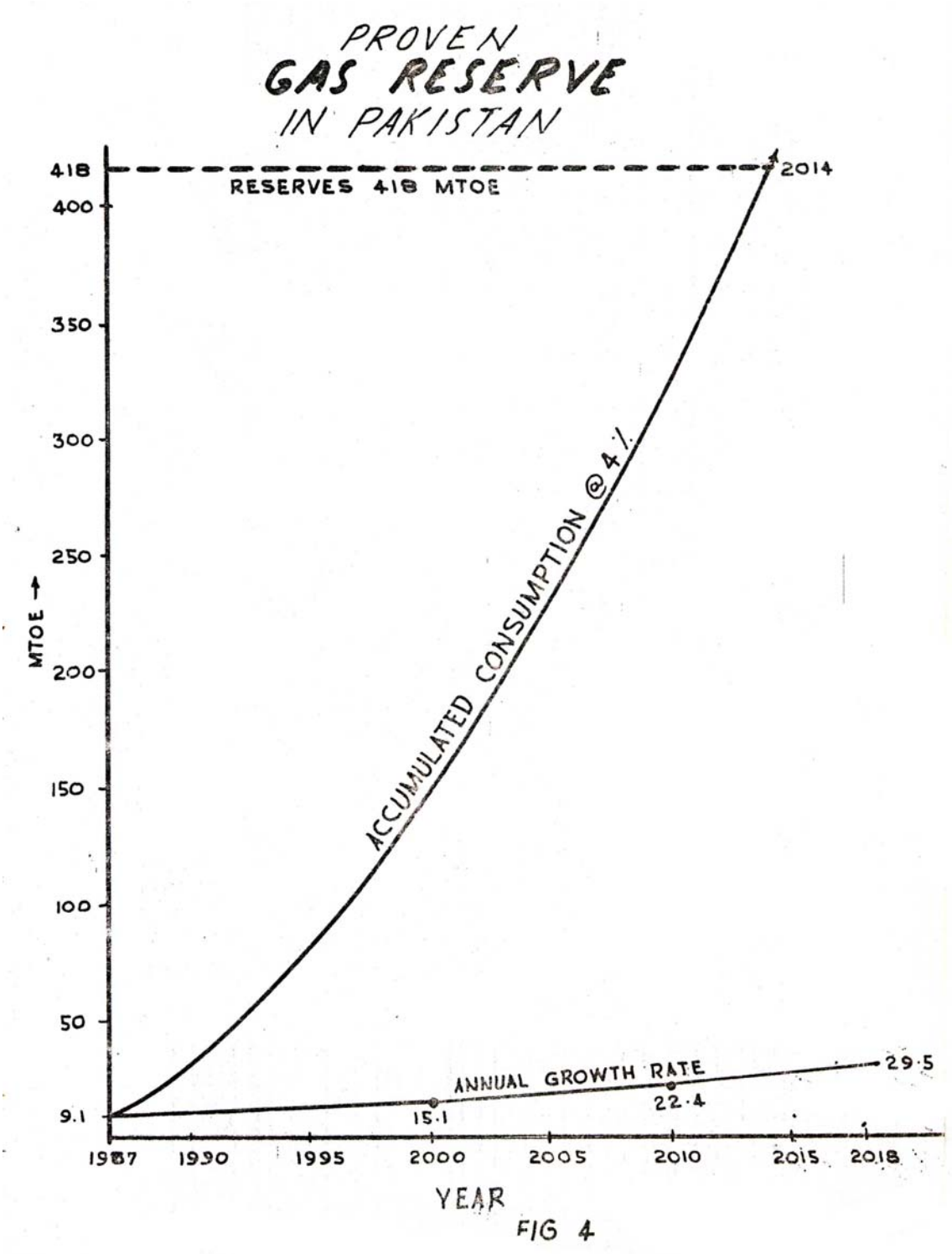

PROVEN
GAS RESERVE
IN PAKISTAN
418
400
350
300
250
200
150
100
50
9.1
MTOE →
RESERVES 418 MTOE
2014
ACCUMULATED CONSUMPTION @ 4 %
ANNUAL GROWTH RATE
15.1
22.4
29.5
1987
1990
1995
2000
2005
2010
2015
2018
YEAR

FIG 4

OIL CONSUMPTION VS RESERVES
IN PAKISTAN

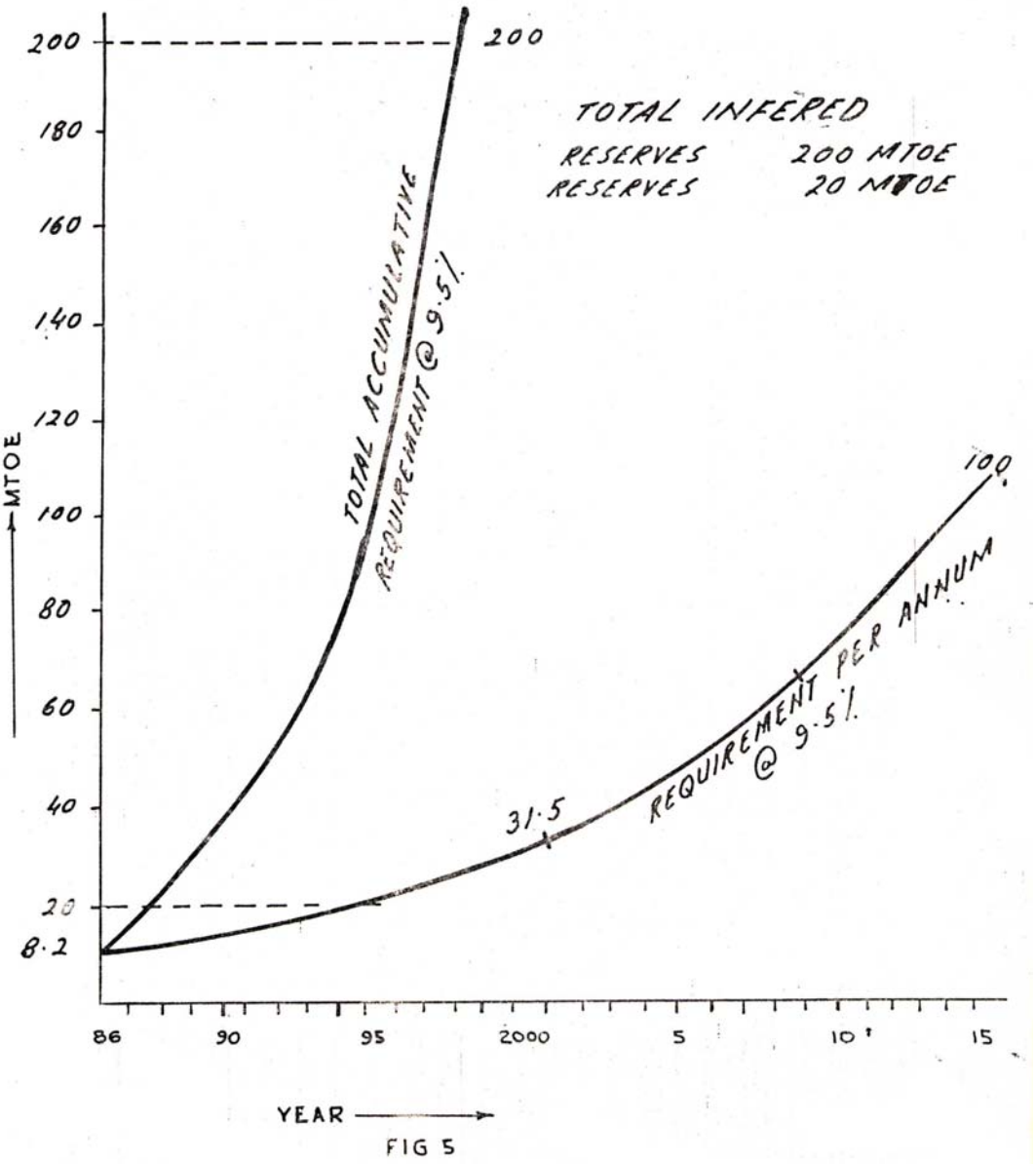


FIG 5

SOLAR CELL COST ALONG WITH STORAGE INSTALLATION

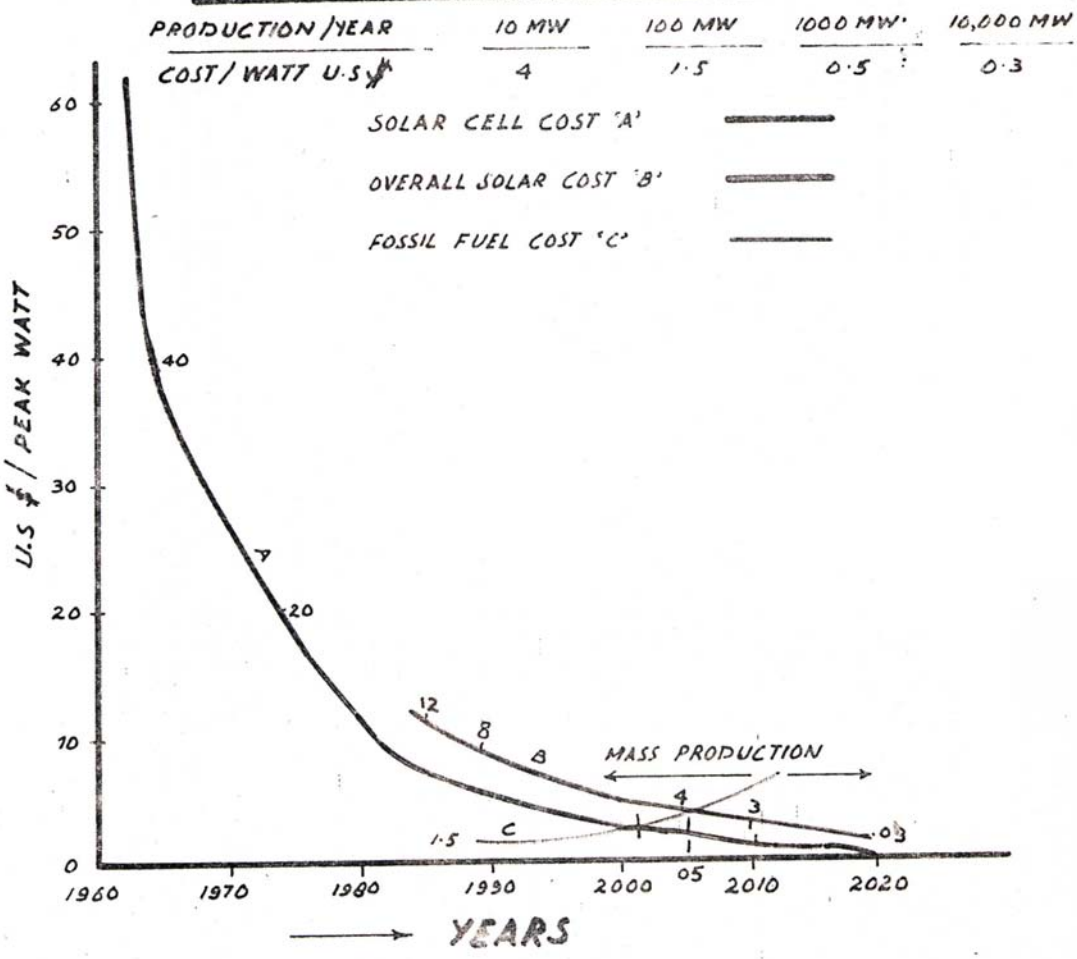


FIG. 6

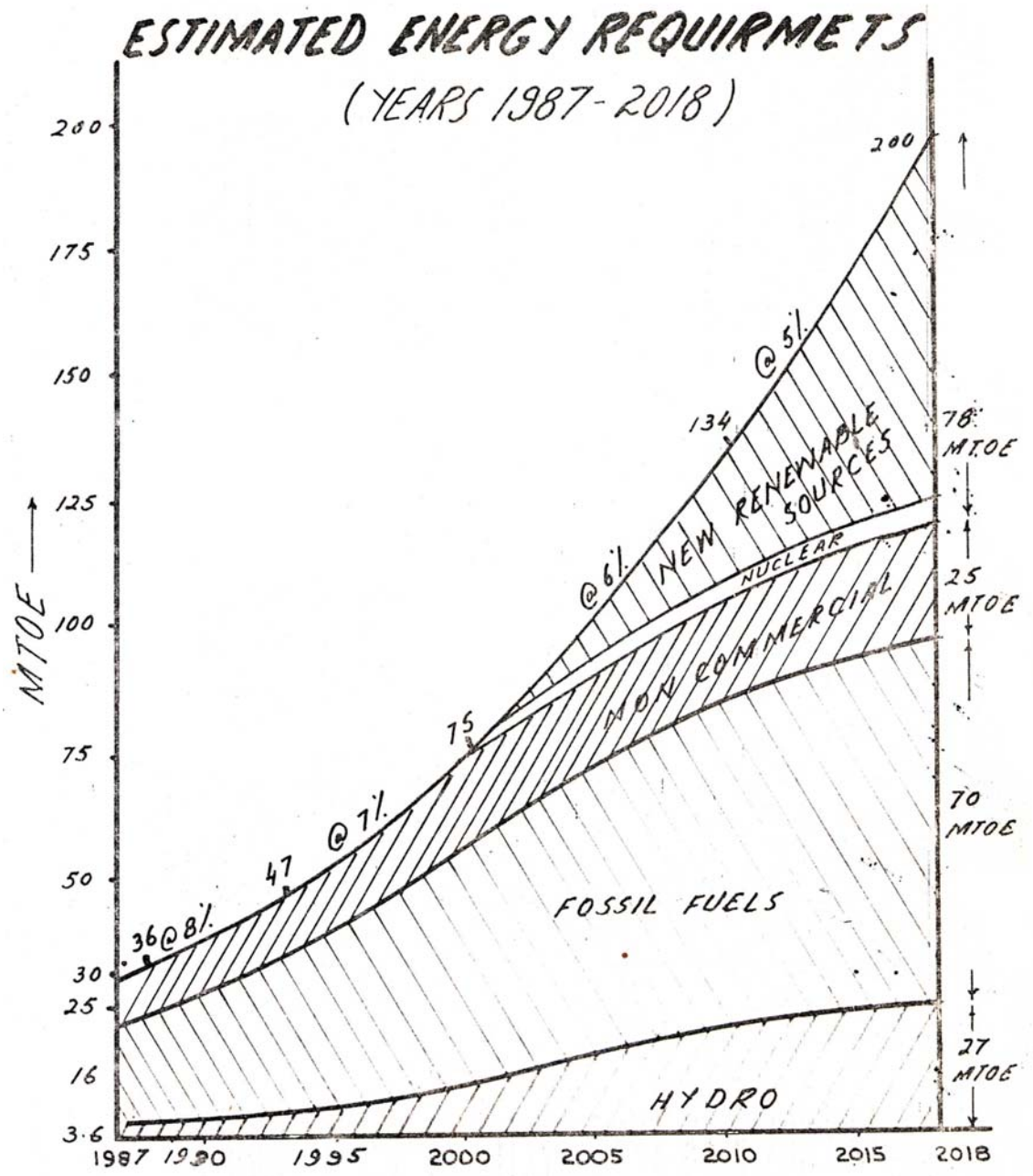

ESTIMATED ENERGY REQUIRMETS
(YEARS 1987-2018)
MTOE
200
175
150
125
100
75
50
30
25
16
3·6
1987
1990
1995
2000
2005
2010
2015
2018
36@8%
47
@7%
75
@6%
134
@5%
200
NEW RENEWABLE SOURCES
NUCLEAR
NON COMMERCIAL
FOSSIL FUELS
HYDRO
78 MTOE
25 MTOE
70 MTOE
27 MTOE

FIG 7

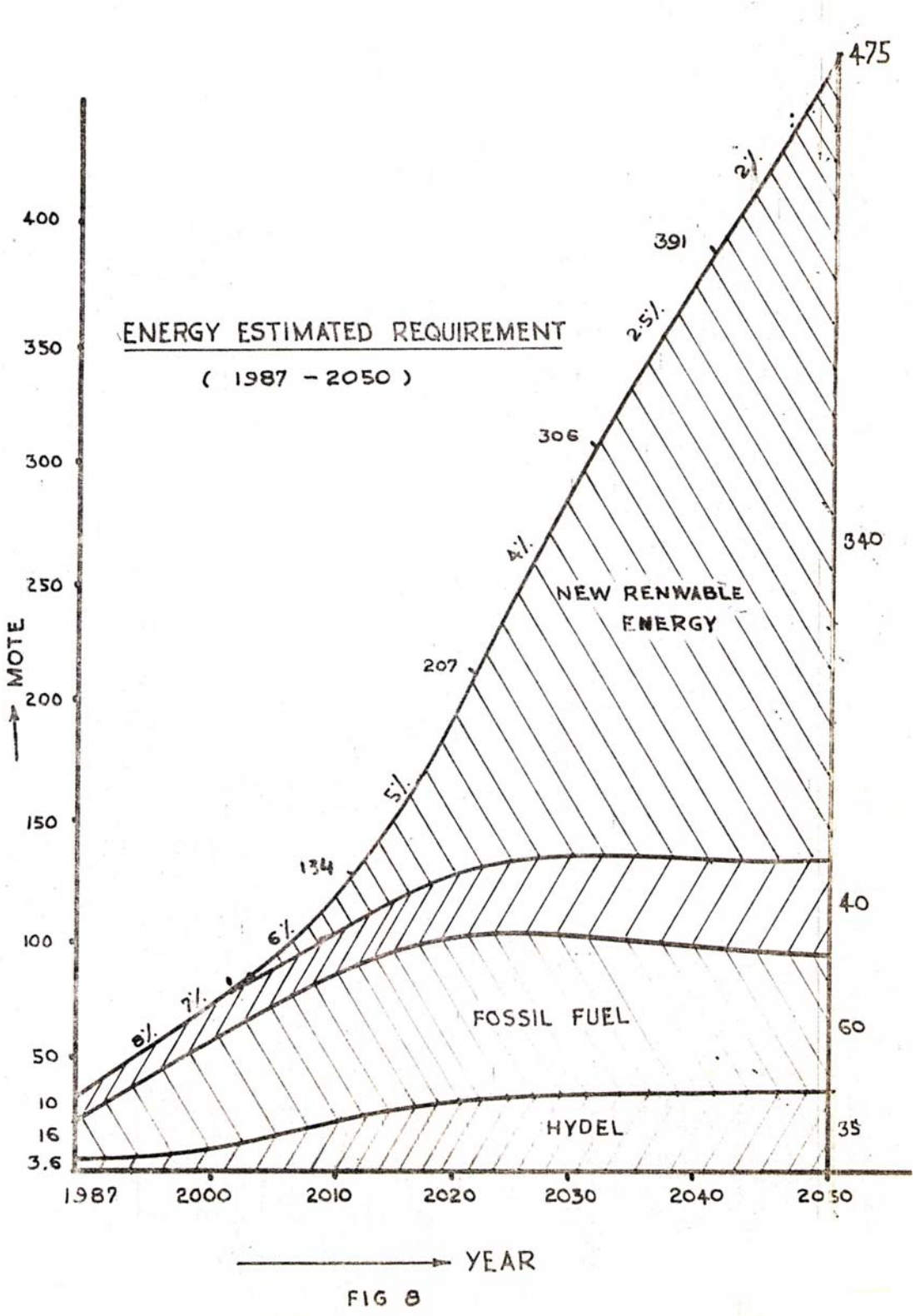

ENERGY ESTIMATED REQUIREMENT
(1987 – 2050)
475
391
306
207
134
2%
2.5%
4%
5%
6%
7%
8%
NEW RENWABLE ENERGY
FOSSIL FUEL
HYDEL
340
40
60
35
400
350
300
250
200
150
100
50
10
16
3.6
MOTE
1987
2000
2010
2020
2030
2040
2050
YEAR

FIG 8

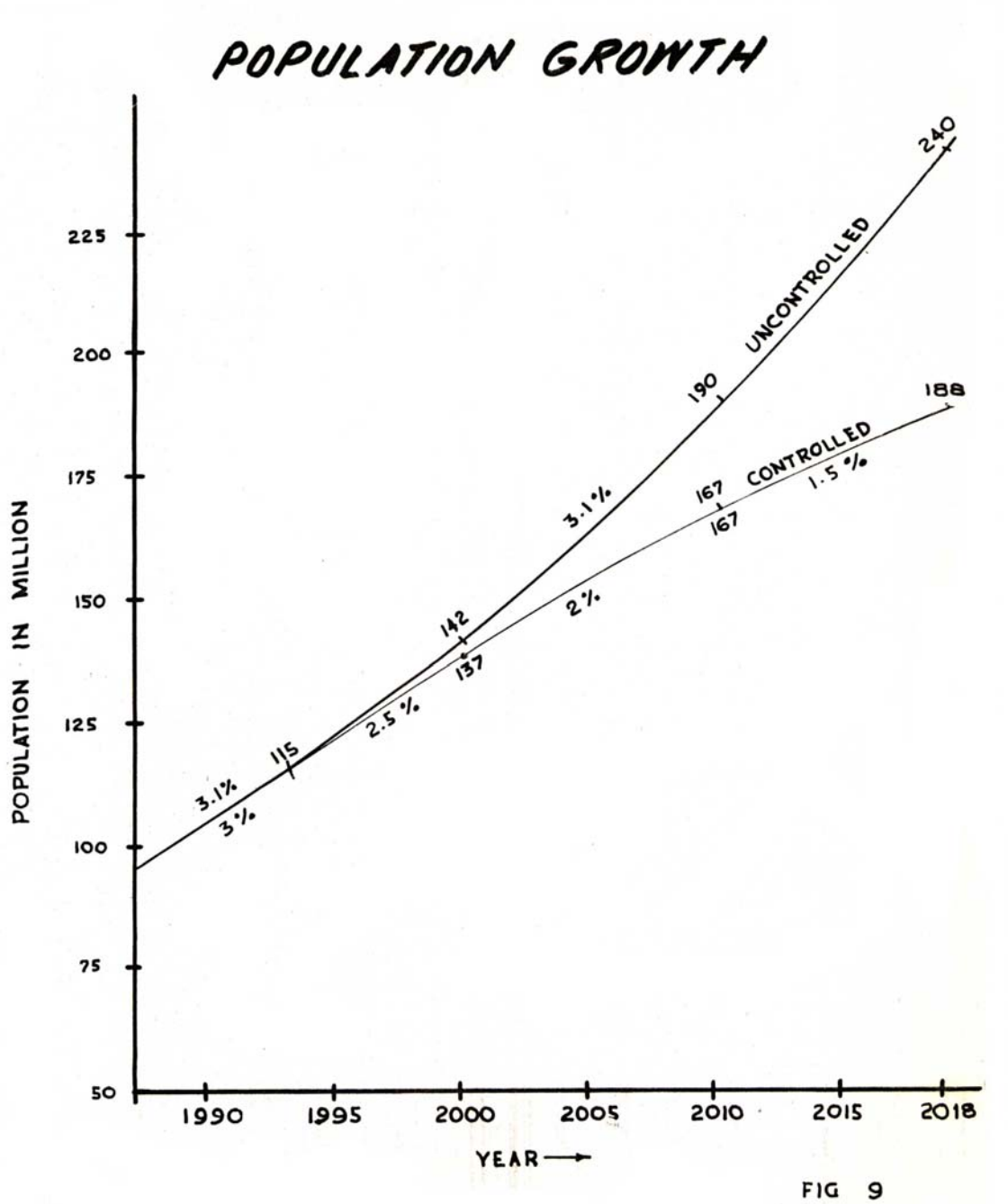
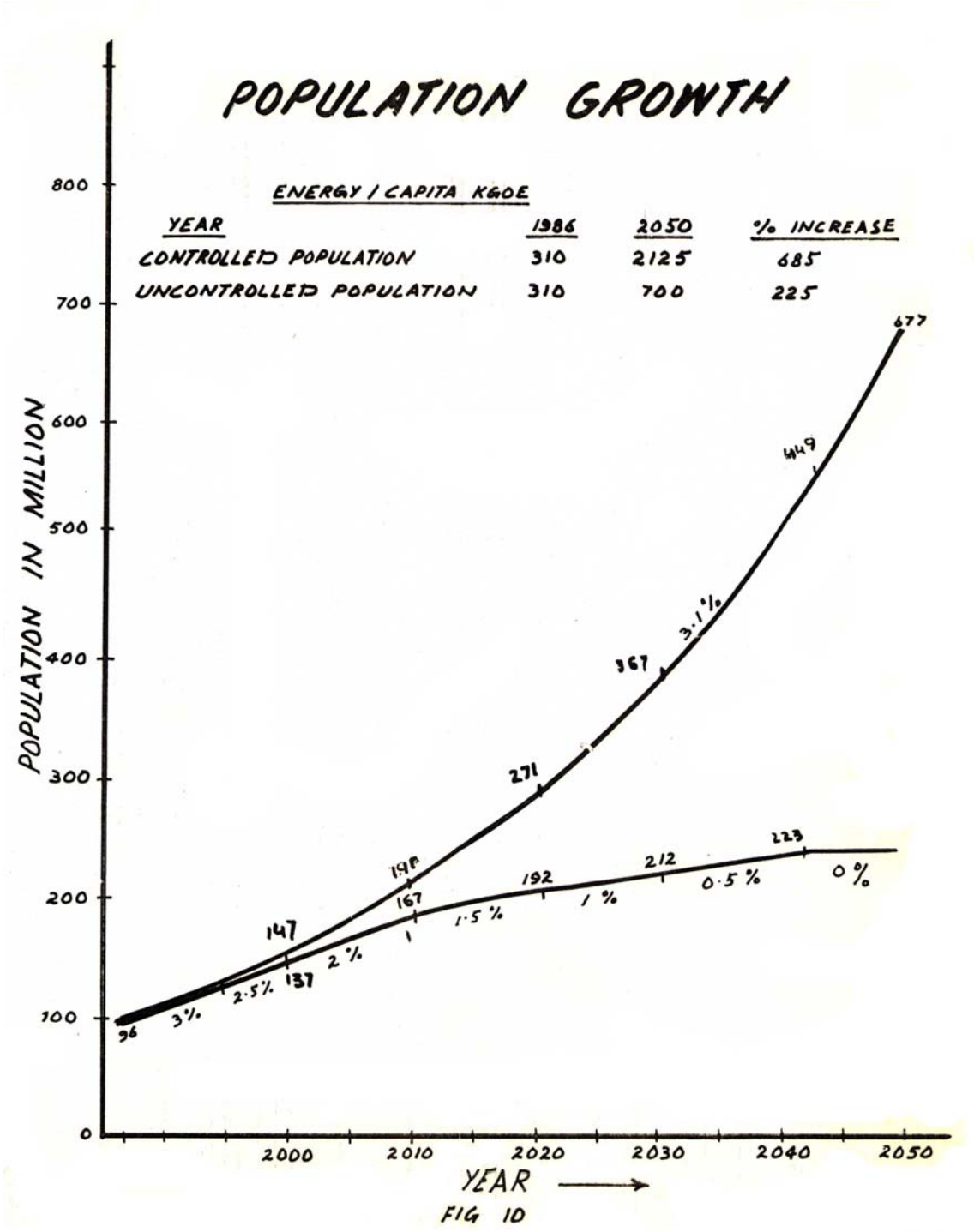

POPULATION GROWTH
POPULATION IN MILLION
225
200
175
150
125
100
75
50
1990
1995
2000
2005
2010
2015
2018
YEAR
3.1%
3%
115
2.5 %
142
137
3.1%
190
UNCONTROLLED
240
2%
167
167
CONTROLLED
1.5 %
188

FIG 9


POPULATION GROWTH
ENERGY / CAPITA KGOE
YEAR 1986 2050 % INCREASE
CONTROLLED POPULATION 310 2125 685
UNCONTROLLED POPULATION 310 700 225
POPULATION IN MILLION
YEAR
800
700
600
500
400
300
200
100
0
2000
2010
2020
2030
2040
2050
96
147
167
192
212
223
271
367
449
677
3%
2.5%
2%
1%
1.5%
1%
0.5%
0%
3.1%
FIG 10