

DEVELOPMENT OF THE MEXICAN ELECTRIC POWER SECTOR

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MEXICO (FIG. 1) HAS A SURFACE OF ALMOST 2 MILLION SQUARE KILOMETERS, BY THE END OF 1980 THE POPULATION WAS OF 68 MILLIONS 15% OF THEM CONCENTRATED IN MEXICO CITY WHICH HAS ABOUT 0.2% OF THE TOTAL AREA OF THE COUNTRY.

BY WORLD STANDARDS MEXICO IS NOT DENSELY POPULATED, HOWEVER IT HAS A FEW AREAS WITH VERY HIGH DEMOGRAPHIC CONCENTRATIONS WHILE OTHERS ARE PRACTICALLY UNPOPULATED, PRESENTING A RATHER UNIQUE SITUATION FOR THE SINGLE ELECTRIC UTILITY RESPONSIBLE OF PROVIDING ELECTRICITY TO THE WHOLE COUNTRY.

REGARDING ECONOMIC GROWTH THE GROSS DOMESTIC PRODUCT HAS SHOWN AN AVERAGE ANNUAL RATE OF 6.3% FOR SEVERAL YEARS AND DURING THE LAST YEAR IT REACHED 7.5%. IN 1980 THE PER CAPITA GDP WAS OF 2261 US DOLLARS. THIS AMOUNT INDICATES THAT THE COUNTRY CAN BE CATEGORIZED AS SEMI-INDUSTRIALIZED AND THAT IN ORDER TO ACHIEVE BETTER STANDARDS, ECONOMIC GROWTH HAS TO CONTINUE AT ABOUT THE OBSERVED RATES OR PERHAPS AT EVEN GREATER RATES, PARTICULARLY IF ONE RECALLS THAT POPULATION GROWS AT 2.9% PER YEAR ACCORDING TO THE LATEST STATISTICS.

COMISIÓN FEDERAL DE ELECTRICIDAD IS THE ONLY ELECTRIC UTILITY IN THE COUNTRY AND ITS PRIMARY TASK CAN BE DEFINED AS
A) PLANNING THE NATIONAL ELECTRIC SYSTEM; B) PRODUCING, TRANSMITTING, TRANSFORMING, DISTRIBUTING AND COMMERCIALIZING THE ELECTRICITY; C) DESIGNING AND BUILDING ALL THE REQUIRED FACILITIES.

FURTHERMORE, COMISIÓN FEDERAL DE ELECTRICIDAD IS ALSO RESPONSIBLE FOR:

- IMPORTS AND EXPORTS OF ELECTRIC ENERGY.
- PROMOTING RESEARCH AND DEVELOPMENT IN THE FIELD OF ELECTRIC POWER, AND
- FACILITATING THE DOMESTIC DEVELOPMENT AND MANUFACTURE OF EQUIPMENT AND MATERIALS REQUIRED BY THE UTILITY.

EXCEPT FOR THE RELATIVELY SMALL ISOLATED SYSTEMS OF THE BAJA CALIFORNIA AND YUCATAN PENINSULAS, THE COUNTRY HAS AN INTERCONNECTED SYSTEM WHOSE 400 KV CIRCUITS COVER ALMOST THE WHOLE COUNTRY, COMPLEMENTED BY TRANSMISSION LINES OPERATING AT 230 KV AND 115 KV.

BY THE END OF 1980 (FIG. 3) THE TOTAL INSTALLED CAPACITY WAS OF 14,600 MW OF WHICH 41% WERE IN HYDROELECTRIC STATIONS, THE REST BEING OIL OR GAS FUELED THERMAL POWER PLANTS, EXCEPT FOR THE 150 MW CERRO PRIETO GEOTHERMAL POWER PLANT. THIS INSTALLED CAPACITY PRODUCED 61,900 MILLION KWH, OF WHICH 73% WERE GENERATED BY THE THERMAL POWER PLANTS.

THE PER CAPITA CONSUMPTION OF ELECTRICITY WAS 910 KWH DURING 1980 CFE SUPPLIED 9.7 MILLION CONSUMERS IN 21,240 CITIES (FIG. 4). OF THE ELECTRICITY SOLD AT THE DIFFERENT RATES (FIG. 5) THE POWER FOR INDUSTRIAL CONSUMPTION REPRESENTED 65% OF THE TOTAL. REGARDING THE TRANSMISSION SYSTEM, CFE HAS INSTALLED 5636 Kms. OF 400 KV LINES WHICH CONSTITUTE THE PRINCIPAL AXIS OF ITS SYSTEM. IS HAS 9,104 Kms. OF 230 KV LINES AS WELL AS 17,199 Kms. OF TRANSMISSION LINES WITH VOLTAGES BETWEEN 161 AND 115 KV:

THE INSTALLED CAPACITY IN TRANSFORMERS AT SUB-STATIONS WAS 62,645 MVA: DURING THE LAST 20 YEARS THE AVERAGE GROWTH RATE HAS BEEN 10% PER YEAR.

THE PRESENT GOVERNMENT HAS PUBLISHED DIFFERENT PLAN FOR DEVELOPING THE COUNTRY (FIG. 7), THE PLAN GLOBAL DE DESARROLLO (GLOBAL DEVELOPMENT PLAN) SETS THE STRATEGY FOR THE OVERALL DEVELOPMENT AND THE PLAN NACIONAL DE DESARROLLO INDUSTRIAL (NATIONAL INDUSTRIAL DEVELOPMENT PLAN) REFERS TO THE INDUSTRIAL SECTOR THAT COMPRISES THE ENERGY SECTOR. THE PROGRAMA DE ENERGIA (ENERGY PROGRAM) DERIVED FROM THE LATTER, FORESEES VERY IMPORTANT INCREASES IN MEXICO'S ECONOMY INDICATING AS A GOAL AN ANNUAL GROWTH OF 8% FOR THE GDP UNTIL 1995, GIVING AS A RESULT VERY HIGH GROWTH RATES FOR THE ELECTRIC SECTOR, WHERE FORECASTS FOR THE NEXT 10 YEARS LIE AROUND 12.5% PER YEAR GRADUALLY DECREASING IN THE LAST DECADE OF THIS CENTURY TO ABOUT 9%.

THE SPECIFIC OBJECTIVES OF THE ENERGY PROGRAM ARE:

TO SATISFY THE NEEDS OF PRIMARY AND SECONDARY ENERGY;
TO RATIONALIZE THE PRODUCTION AND USE OF ENERGY; TO DIVERSIFY THE SOURCES OF PRIMARY ENERGY LENDING SPECIAL ATTENTION TO RENEWABLE RESOURCES; TO INTEGRATE THE ENERGY SECTOR INTO THE DEVELOPMENT OF THE REST OF THE ECONOMY; TO KNOW MORE PRECISELY THE COUNTRY'S ENERGY RESOURCES AND TO STRENGTHEN THE SCIENTIFIC AND TECHNICAL INFRASTRUCTURE IN ORDER TO DEVELOP THE VARIOUS ENERGY POTENTIALS, AND TO INCORPORATE NEW TECHNOLOGIES IN THE ENERGY FIELD.

BESIDES HYDROCARBONS FOR THE PRODUCTION OF ELECTRICITY, HYDROELECTRIC POWER, GEOTHERMAL ENERGY AND COAL HAVE BEEN DEVELOPED AND THE FIRST NUCLEAR POWER PLANT IS BEING BUILT.

THE OBJECTIVES OF THE ENERGY PROGRAM ARE TRANSLATED INTO THE PROGRAMA DE OBRAS E INVERSIONES DEL SECTOR ELECTRICO (FIG. 9) (INVESTMENT PROGRAM OF THE ELECTRIC SECTOR) (FIG. 9) COVERING A PERIOD OF 10 YEARS. THE CURRENT PROGRAM SHOWS THE CAPACITY ADDITIONS FOR THE DIFFERENT TYPES OF POWER GENERATING STATIONS, SCHEDULED TO BE COMMISSIONED OVER THE NEXT TEN YEARS. THIS PROGRAM IS REVIEWED EVERY YEAR IN THE LIGHT OF PAST PERFORMANCE AND UPDATED FORECASTS OF DEMAND.

LONG TERM PLANNING IMPLIES A DETAILED EVALUATION OF THE ENERGY RESOURCES FOR THE GENERATION OF ELECTRICITY, THE INVENTORY OF THE HYDROELECTRIC POTENTIAL SHOWS THAT, IN THEORY, HYDROELECTRICITY (FIG. 10) COULD BE DEVELOPED TO OBTAIN A TOTAL YEARLY GENERATION OF 170 TWH OF WHICH THE BASINS OF THE GRIJALVA AND USUMACINTA RIVERS REPRESENT 40%, THE BASINS OF THE PAPALOAPAN AND BALSAS RIVERS 17% EACH, THE REST CORRESPONDING TO THE BASINS OF THE STATES OF SONORA AND SINALOA AND TO THE LERMA-SANTIAGO RIVER. NEVERTHELESS, THE DEVELOPMENT OF ALL OF THE PROJECTS INVOLVED IN THIS HYDROELECTRIC POTENTIAL IS IN MANY CASES STILL IN THE PHASE OF IDENTIFICATION; WE HAVE BEEN WORKING ON A BETTER DEFINITION OF THE MOST IMPORTANT PROJECTS FROM THE POINT OF VIEW OF THE MAGNITUDE OF THEIR POSSIBLE GENERATION AND HAVE FOUND THAT, IN THE MOST OPTIMISTIC CASE, FOR THE YEAR 2000 WE COULD COUNT ON A MEDIUM ANNUAL HYDROELECTRIC GENERATION OF 80 TWH WHICH IMPLIES THAT IN THESE NEXT 20 YEARS WE MUST QUADRUPLE HYDROELECTRIC CAPACITY.

COAL HAS NOT PLAYED A MAJOR ROLE IN ELECTRICITY PRODUCTION UNTIL NOW, HOWEVER PLANS ARE BEING IMPLEMENTED TO I THIS RESOURCE. THE COAL PRODUCING REGION (FIG. 11) HAS TRADITIONALLY BEEN THE STATE OF COAHUILA; EXPLORATIONS MADE IN THE BASIN OF RIO ESCONDIDO SHOW STEAM COAL IN SUFFICIENT QUANTITY TO FEED 2 GENERATING STATIONS, THE FIRST ONE WITH A CAPACITY OF 1,200 MW IS BEING BUILT AND ITS FIRST UNIT WILL BE IN COMMERCIAL OPERATION BY NEXT OCTOBER, THE SECOND PLANT WILL HAVE 1,400 MW AND WILL START GENERATING BY MID 1985. IN THIS SAME AREA CFE CONTINUES THE EXPLORATORY ACTIVITIES IN ORDER LOCATE MORE STEAM COAL SINCE IT IS PLANED TO HAVE, BY THE YEAR 2000, AN ANNUAL GENERATION OF 40 TWH FROM COAL FIRED POWER PL

BECAUSE OF ITS GEOLOGICAL CHARACTERISTICS (FIG. 1 MEXICO HAS POSSIBILITIES OF USING GEOTHERMAL ENERGY TO GENERA ELECTRICITY AND MORE THAN 300 SITES WITH THERMAL MANIFESTATIO HAVE BEEN FOUND.

NEAR THE GEOTHERMAL POWER PLANT OF CERRO PRIETO W PRESENT CAPACITY IS 180 MW THE POSSIBILITY OF INSTALLING AND ADDITIONAL CAPACITY OF 600 MW HAS BEEN ESTABLISHED. ESTIMATE INDICATE A POTENTIAL CAPACITY OF THE ORDER OF ONE MILLION KW THIS AREA.

ANOTHER REGION WHERE WORK IS IN PROCESS TO INSTALL GEOTHERMAL UNITS IS "LOS AZUFRES", MICHOACÁN, WHERE WE NOW HAVE MORE THAN 22 WELLS WHICH HAVE GIVEN EXCELLENT RESULTS; IN THIS AREA WE HAVE HAD SOME DIFFICULTIES DUE TO THE VOLCANIC GEOLOGY WHICH IS DIFFERENT IN PROBLEMS AND SYSTEMS FROM OTHER FIELDS.

AS A TECHNICAL INNOVATION WE HAVE PLANNED IN LOS AZUFRES, THE PROVISIONAL INSTALLATION OF 5 GENERATING UNITS WITH A CAPACITY OF ABOUT 5 MW EACH IN ORDER TO START USING THE ENERGY AS SOON AS POSSIBLE. MEANWHILE, DESIGN OF THE STEAM GATHERING SYSTEM AND THE POWER PLANT IS PROGRESSING.

THE FIELD OF LOS AZUFRES PRESENTS THE POSSIBILITY OF INSTALLATION BETWEEN 300 AND 600 MW; PARALLEL TO THIS, OTHER FIELDS ARE BEING EXPLORED IN ORDER TO SEE WHICH GEOTHERMAL FIELDS HAVE THE BEST CHARACTERISTICS TO DEVELOP THE ESTIMATED 20 TWH SCHEDULED TO BE GENERATED BY THIS TYPE OF RESOURCES IN YEAR 2000.

THE FORECASTED DEMAND OF ELECTRIC ENERGY BY THE YEAR 2000 CALLS FOR THE GENERATION (FIG. 13) OF ABOUT 410 TWH WITH OIL, GAS OR NUCLEAR POWER PLANTS. THIS AMOUNT IS THE DIFFERENCE BETWEEN THE EXPECTED NEEDS AND THE ENERGY THAT COULD BE GENERATED FROM COAL, GEOTHERMAL AND HYDROELECTRIC POWER PLANTS, UNDER A VIGOROUS DIVERSIFICATION PROGRAM.

ACCORDING TO THE ENERGY PROGRAM A GOAL OF 20,000 OF INSTALLED CAPACITY IN NUCLEAR POWER HAS BEEN ESTABLISHED FOR THE END OF THE CENTURY. THIS WOULD PRODUCE ABOUT 130 TWH LEAVING SOME 280 TWH TO BE GENERATED IN 2000 BY THERMAL POWER PLANTS FUELED WITH OIL OR GAS, WHOSE CAPACITY WOULD BE OF ABOUT 43,000 MW:

PROVEN URANIUM RESERVES AMOUNT TO SOME 10,000 TON OF U_3O_8 , BUT PROSPECTION AND GEOLOGICAL STUDIES INDICATE GOOD POSSIBILITIES FOR URANIUM ORE DEPOSITS IN THIS COUNTRY, THAT COULD FEED THE REQUIREMENTS OF THE NUCLEAR POWER PLANTS REQUIRED TO COMPLETE THE DIVERSIFICATION OF PRIMARY ENERGY RESOURCES CALLED FOR IN THE ENERGY PROGRAM.

TO STUDY THE IMPLICATIONS OF SUCH AN IMPORTANT NUCLEAR POWER PROGRAM THREE REACTOR TYPES PWR, BWR, AND HWR WERE SELECTED AND THREE CONSULTANTS SOFRATOME FROM FRANCE, ASEA-ATOM FROM SWEDEN AND AECL FROM CANADA WERE CONTRACTED TO ANALYSE THE SITUATION ACCORDING TO THE FOLLOWING GUIDELINES:

- DETERMINATION OF THE DEMANDS FOR MATERIALS, EQUIPMENT, COMPONENTS AND SERVICES.
- PERSONNEL AND TRAINING REQUIREMENTS FOR THE ELECTRIC SECTOR, THE MANUFACTURING INDUSTRY, THE FUEL CYCLE AND THE RESEARCH AND DEVELOPMENT ACTIVITIES.
- POSSIBILITIES FOR TRANSFER OF TECHNOLOGY AND ITS ABSORPTION BY THE MEXICAN INSTITUTIONS INVOLVED IN THE PROGRAM.
- INVESTMENTS IN POWER PLANTS, FUEL CYCLE AND OPERATING COSTS AND ESTIMATES OF INVESTMENTS IN INDUSTRY AND RESEARCH FACILITIES.

ACCORDING TO THE REPORTS OF THE THREE CONSULTANTS, THE POSSIBILITIES OF DEVELOPING A NATIONAL NUCLEAR INDUSTRY ARE MORE DEPENDANT ON THE SIZE OF THE NUCLEAR POWER PROGRAM AND THE WILL OF MÉXICO TO MOVE AHEAD THAN ON THE TYPE OF REACTOR.

ASIDE FROM THE DRAWBACKS OF TECHNOLOGICAL DEPENDENCE, MÉXICO COULD HARDLY BE ABLE TO PAY FOR THE IMPORTS OF ALL THE EQUIPMENT AND FUEL. FOR THESE REASONS THE PROGRAM HAS TO ENVISAGE THE DEVELOPMENT OF A NATIONAL NUCLEAR INDUSTRY.

THE RESULTS OF THE STUDIES SHOW THAT REGARDLESS THE REACTOR TYPE A PROGRAM OF ABOUT 20,000 MW MAKES IT ECONOMIC TO INCREASE THE LOCAL CONTENT OF THE NUCLEAR POWER PLANTS, AND THE COMPLETE FUEL CYCLE, SO THAT BY THE END OF THE CENTURY MORE THAN 80% OF INTEGRATION COULD BE ACHIEVED.

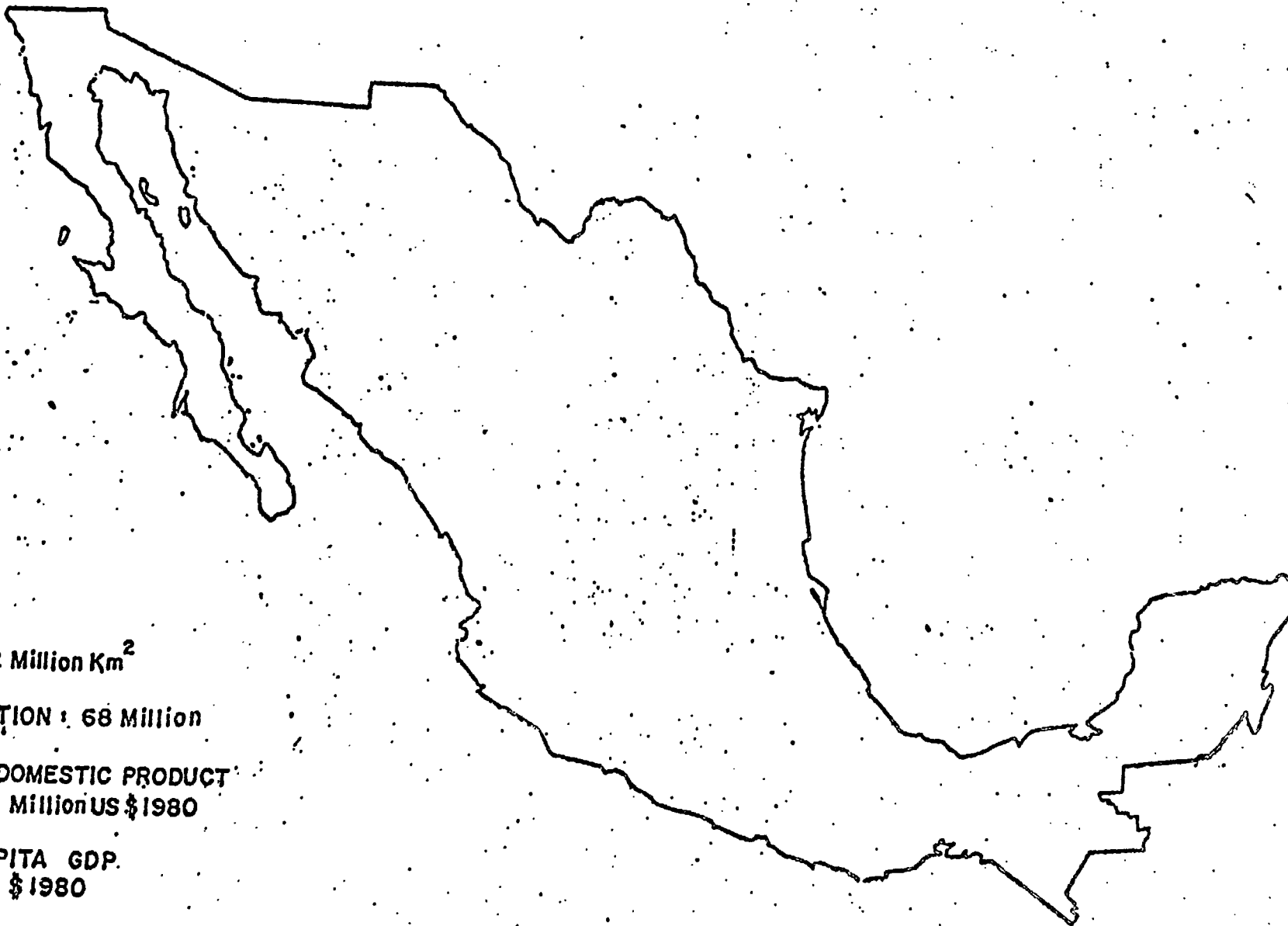
THE 20,000 MW CAPACITY IN NUCLEAR POWER WILL NOT BE REALLY SIGNIFICANT IN THE OVERALL ENERGY BALANCE OF THE COUNTRY BY THE END OF THE CENTURY, BUT IF THE PROGRAM IS SUCCESSFUL, WE COULD DEVELOP IN TWENTY YEARS THE CAPABILITY OF INSTALLING, WITH ITS OWN RESOURCES, SOME FIVE TO SIX LARGE NUCLEAR POWER PLANTS PER YEAR, SO THAT EARLY NEXT CENTURY, NUCLEAR ENERGY WILL REALLY HAVE A SHARE IN THE TOTAL ENERGY SUPPLY OF THE CENTURY. THE DECISION TO INITIATE THE NUCLEAR POWER PROGRAM IS BEING CONSIDERED AT PRESENT AND TENTATIVELY CFE IS RECOMMENDING TO START THE PROGRAM WITH THE CONSTRUCTION OF ONE OR TWO POWER PLANTS WITH A RELATIVELY IMPORTANT PARTICIPATION OF THE SELECTED SUPPLIERS OF NUCLEAR SYSTEMS, PROBABLY BY ASKING THEM TO SUPPLY NUCLEAR ISLANDS. THE INFORMATION SUBMITTED FOR THE FIRST STEP AS WELL AS FOR SUPPORT ON THE FOLLOWING STAGES SHOULD MAKE IT POSSIBLE TO COME TO A DECISION IN A REASONABLE TIME.

TO CONCLUDE LET ME EMPHASIZE THAT OUR CHALLENGE FOR CFE IS TO COPE WITH A SEVEN FOLD INCREASE IN DEMAND OVER A PERIOD OF TWENTY YEARS, REQUIRING THE INSTALLATION OF DIFFERENT TYPES OF GENERATING PLANT, LOCATED ALL OVER THE COUNTRY, AND DEVELOP THE NECESSARY HUMAN RESOURCES AND ORGANIZATION TO COPE WITH ALL THE REQUIREMENTS.



COMISION FEDERAL DE ELECTRICIDAD

MEXICO 1980



AREA: 2 Million Km²

POPULATION: 68 Million

GROSS DOMESTIC PRODUCT
154,579 Million US \$ 1980

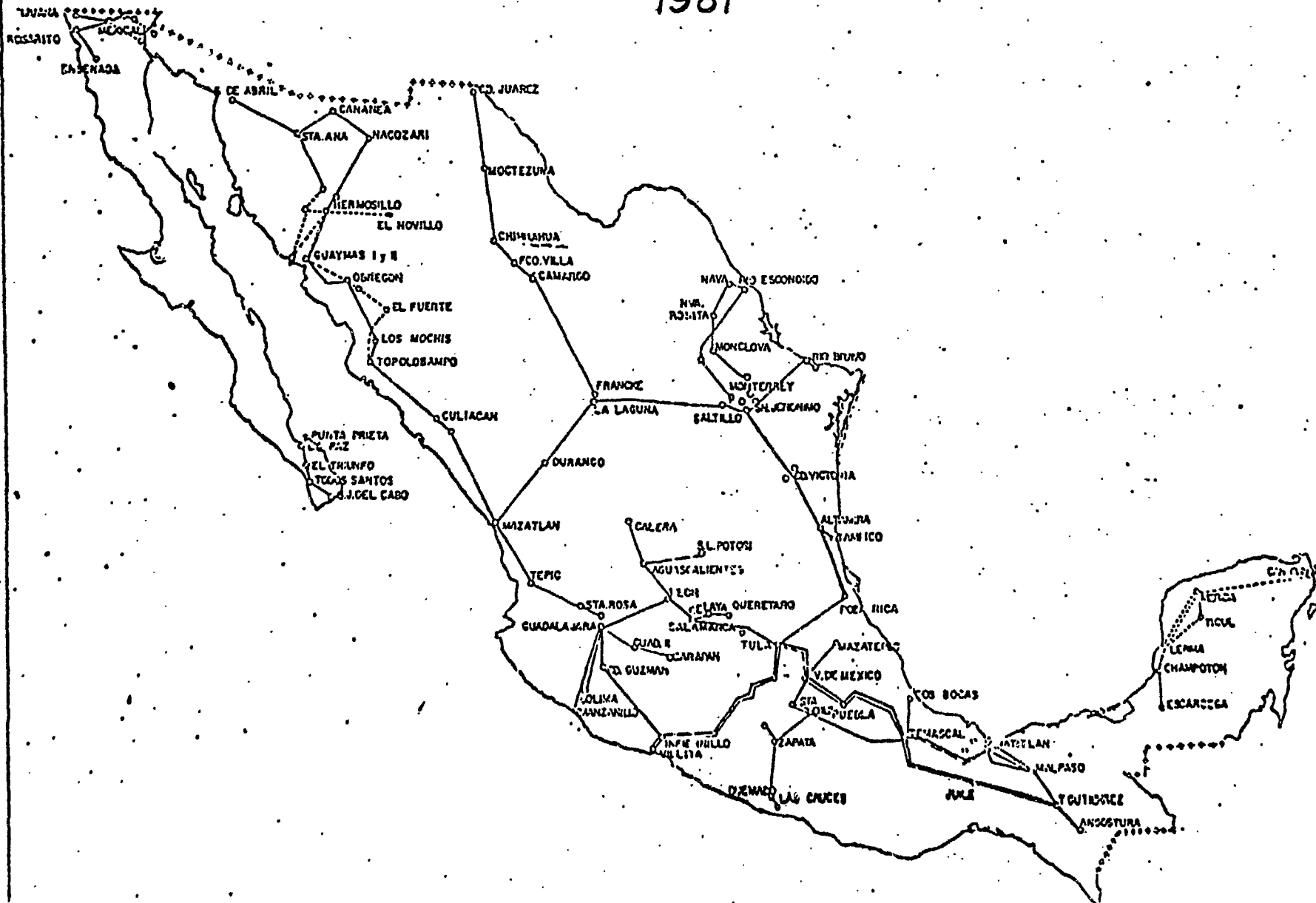
PER CAPITA GDP.
2,261 US \$ 1980



COMISION FEDERAL DE ELECTRICIDAD

MEXICAN TRANSMISSION GRID

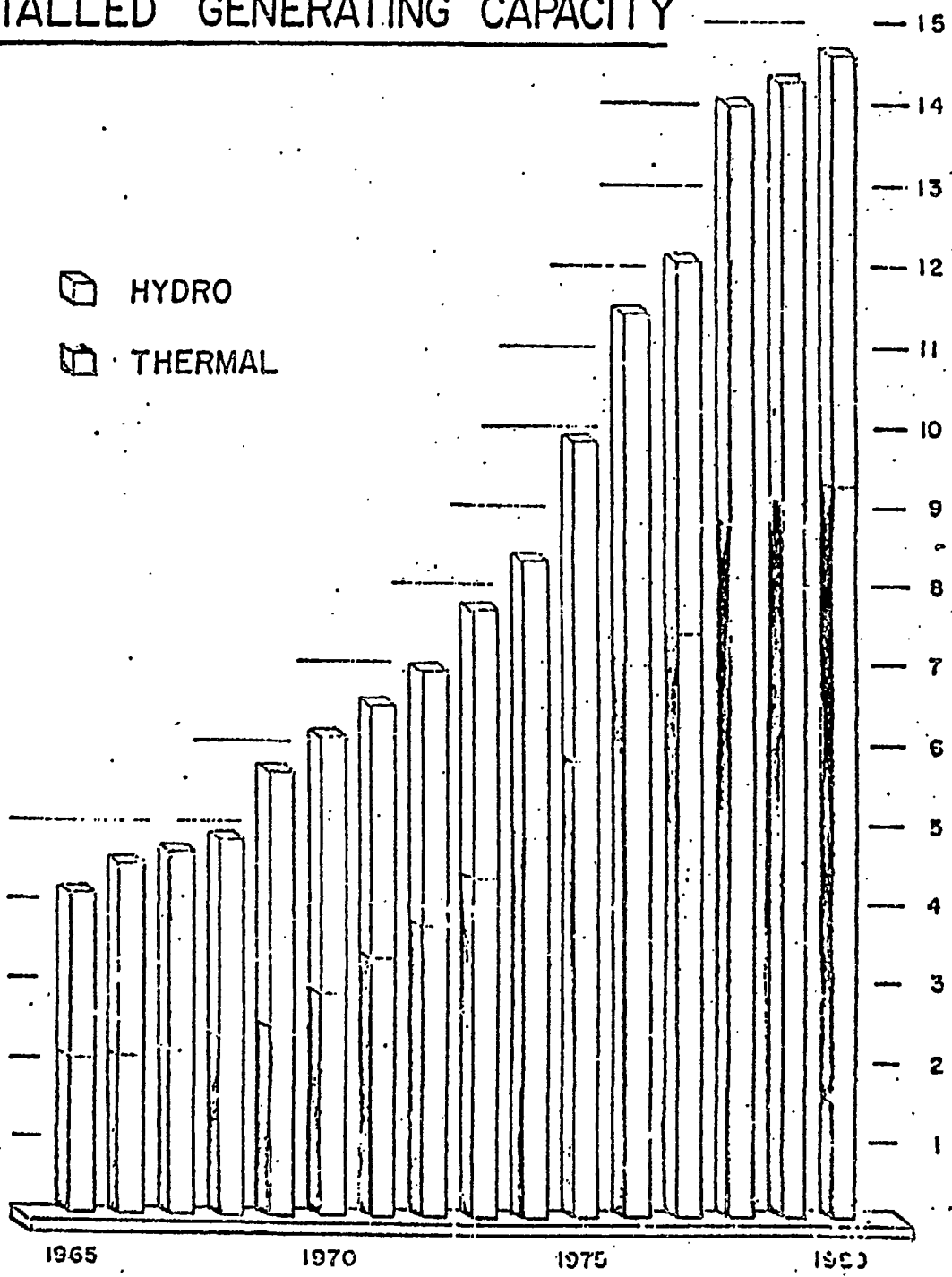
1981



INSTALLED GENERATING CAPACITY

$\text{KW} \times 10^6$

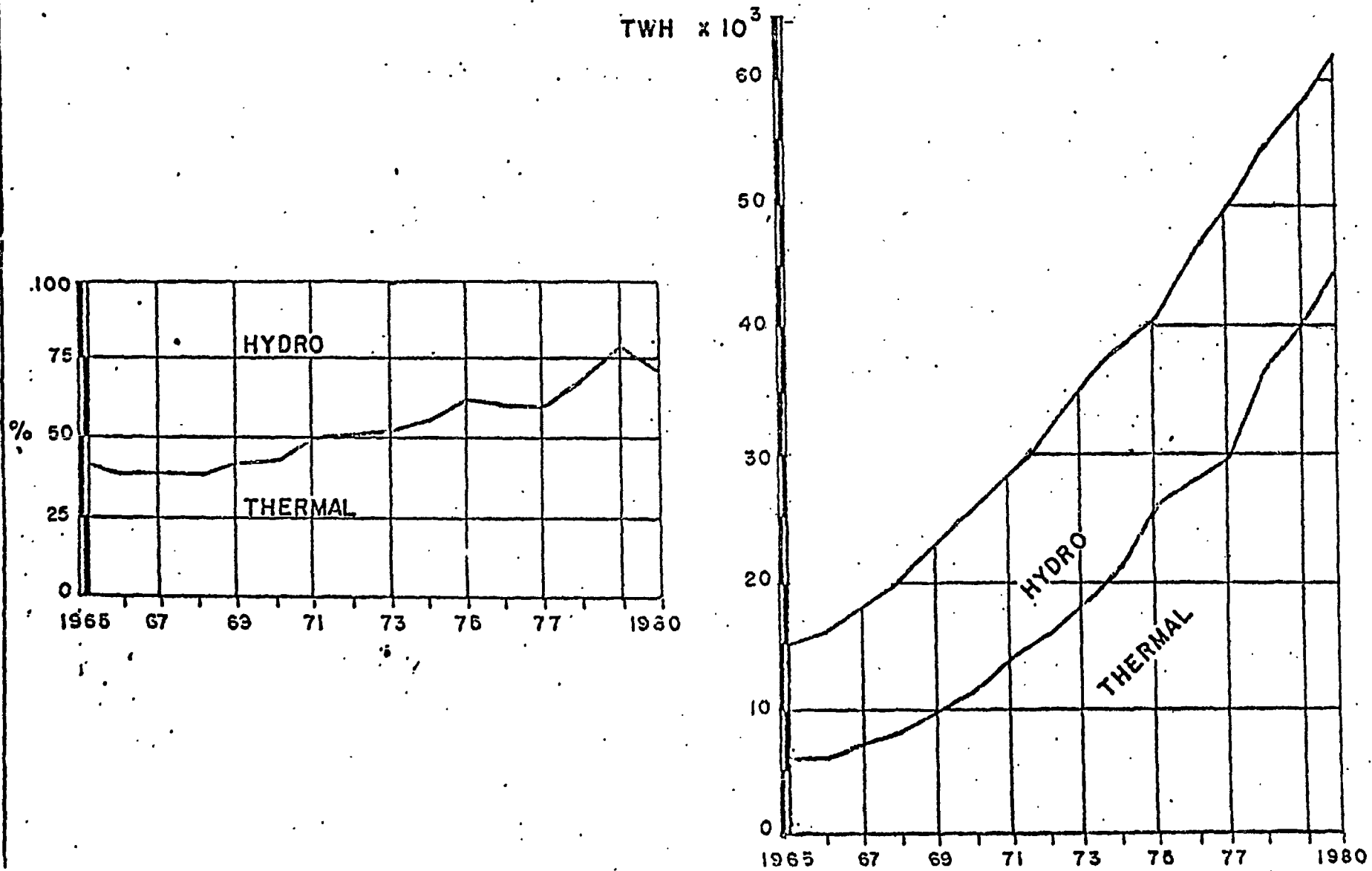
HYDRO
THERMAL

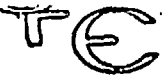




COMISION FEDERAL DE ELECTRICIDAD

ENERGY PRODUCTION





COMISION FEDERAL DE ELECTRICIDAD

C.F.E. 1980

CONSUMERS (THOUSANDS)	9,720
CITIES SERVED	21,240
INDUSTRIAL CONSUMPTION	65 %
TRANSMISSION LINES	
400 kV	5,636 km.
230 kV	9,104 km.
115 and 161 kV	17,199 km
SUBSTATIONS	62,645 MVA



COMISION FEDERAL DE ELECTRICIDAD

GLOBAL DEVELOPMENT PLAN

INDUSTRIAL DEVELOPMENT PLAN

ENERGY PROGRAM

MEXICAN FOOD SYSTEM

URBAN DEVELOPMENT PLAN

FISHERY DEVELOPMENT PLAN



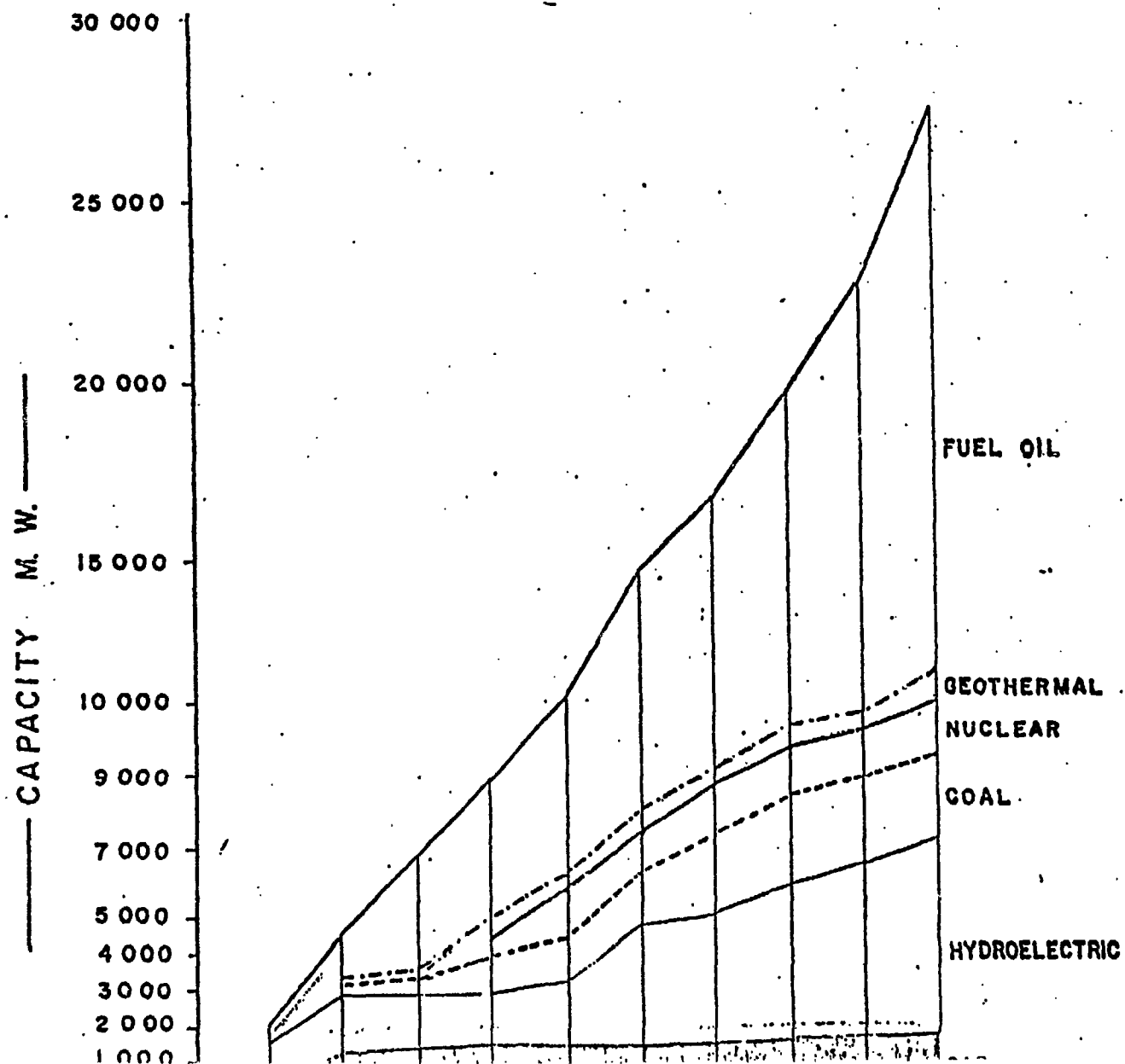
ENERGY PROGRAM

1. SATISFACTION OF NATIONAL ENERGY DEMAND
2. RATIONALIZATION OF ENERGY USE
3. DIVERSIFICATION OF PRIMARY ENERGY SOURCES
4. INTEGRATION OF THE ENERGY SECTOR ECONOMIC DEVELOPMENT
5. QUANTIFICATION OF DOMESTIC ENERGY RESOURCES
6. STRENGTHENING TECHNICAL AND SCIENTIFIC INFRASTRUCTURE



COMISION FEDERAL DE ELECTRICIDAD

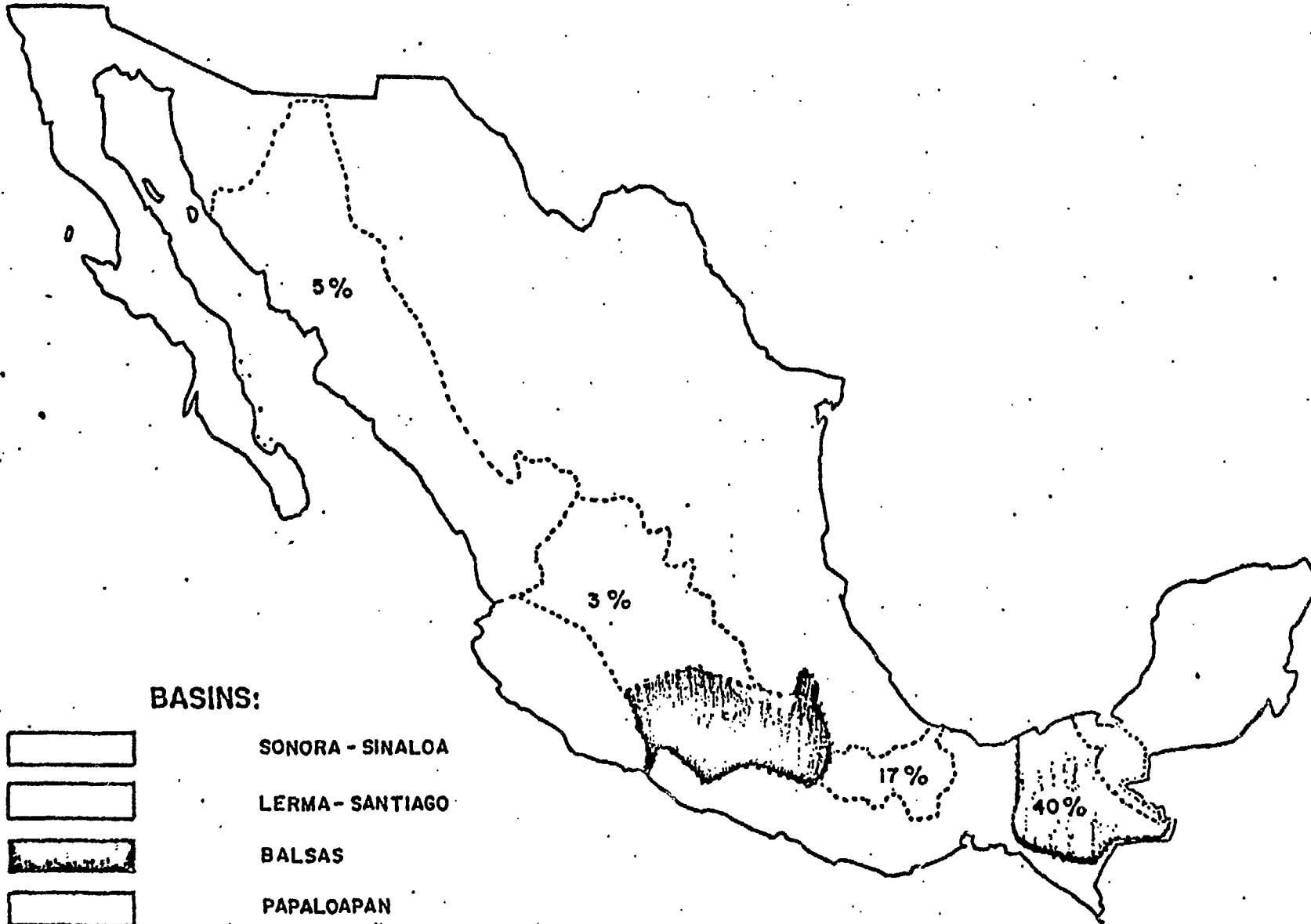
CAPACITY ADDITIONS BY SOURCE



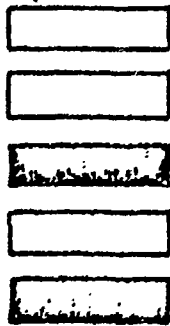


COMISION FEDERAL DE ELECTRICIDAD

HYDROELECTRIC POTENTIAL



BASINS:



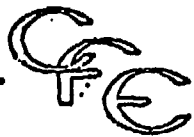
SONORA - SINALOA

LERMA - SANTIAGO

BALSAS

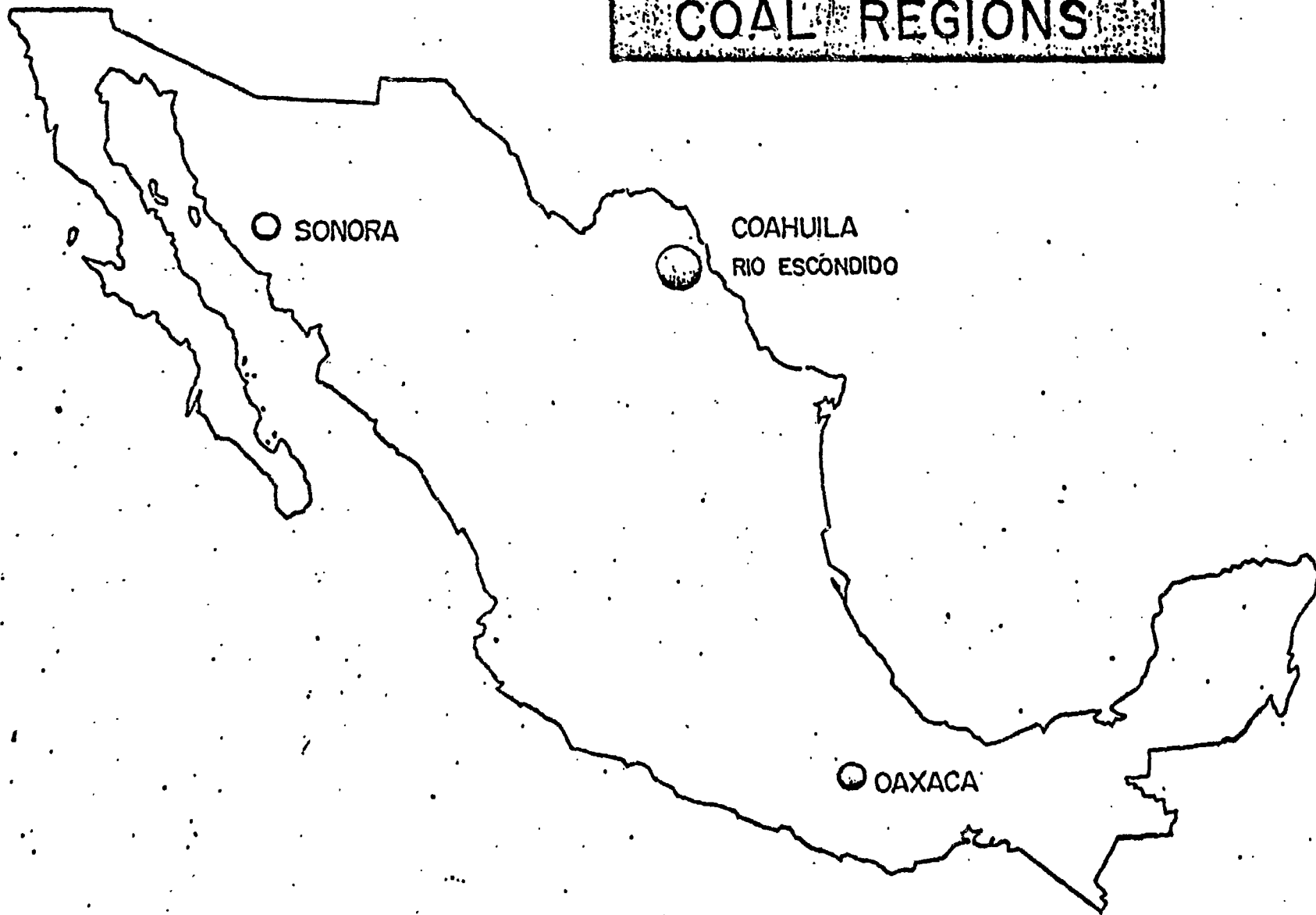
PAPALOAPAN

GRIJALVA - USUMACINTA



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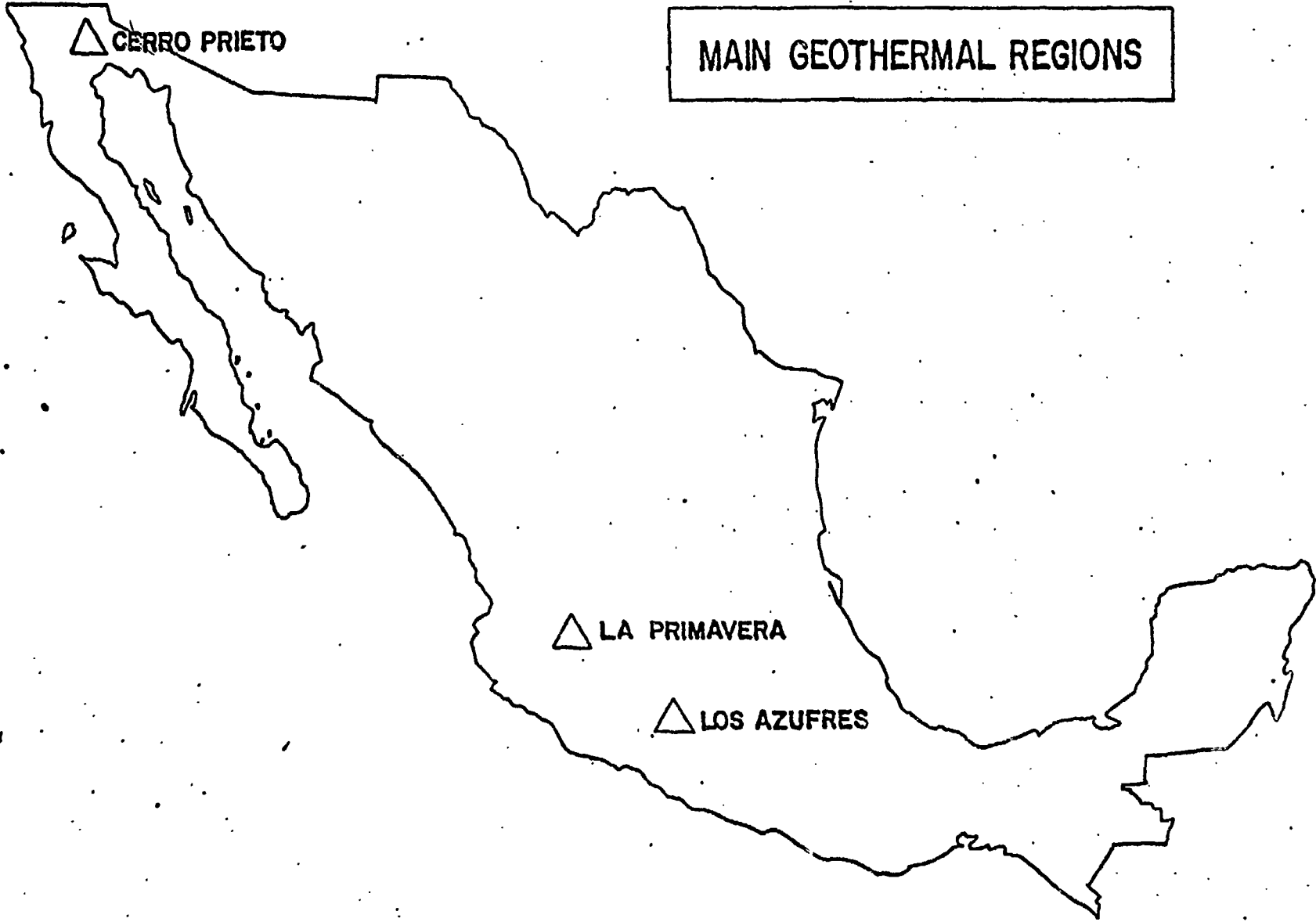
COAL REGIONS





COMISION FEDERAL DE ELECTRICIDAD

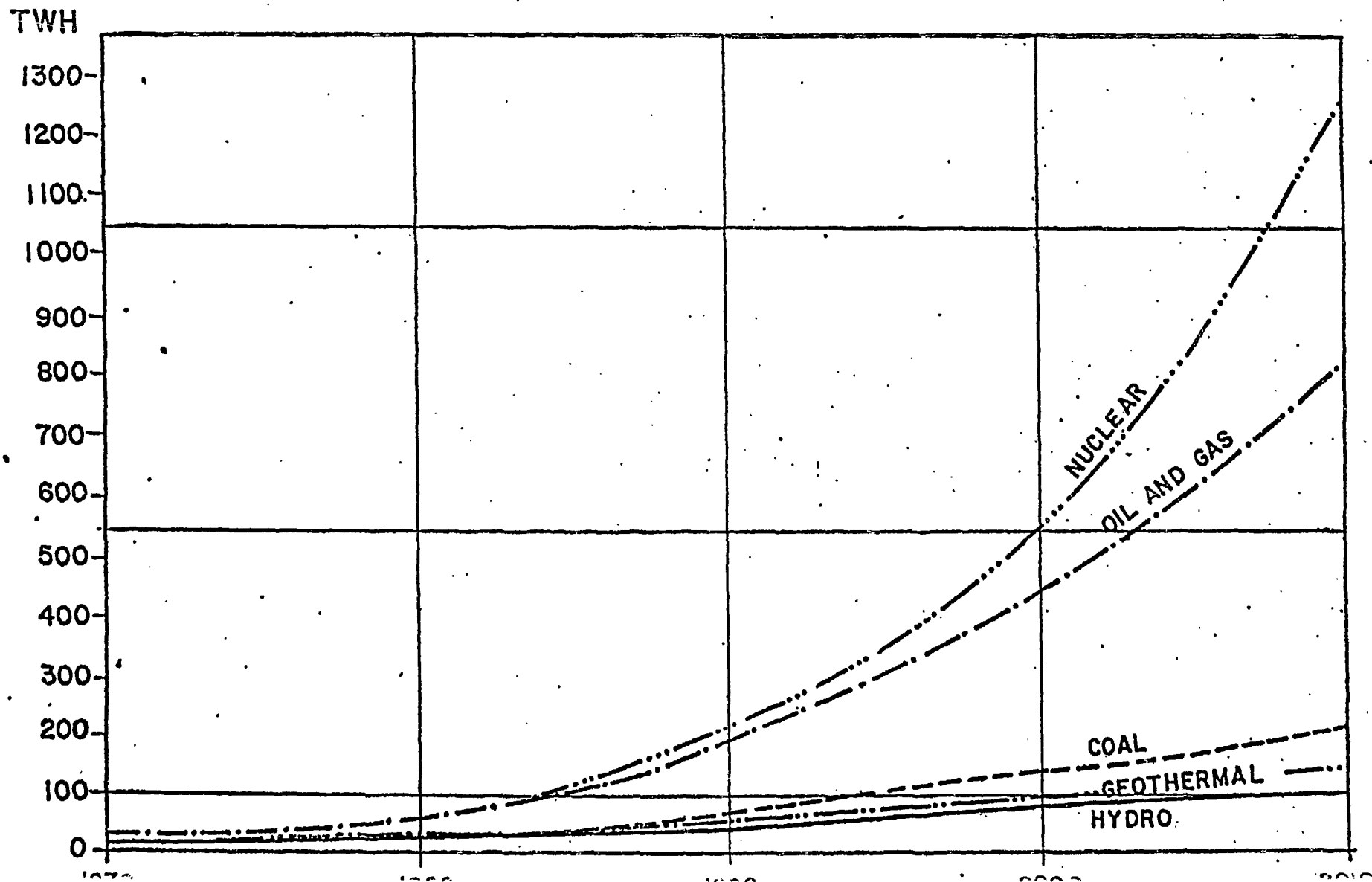
MAIN GEOTHERMAL REGIONS





COMISION FEDERAL DE ELECTRICIDAD

ELECTRIC ENERGY SUPPLY



ELECTRIC ENERGY GENERATION BY SOURCE

YEAR 2000

	TWH
HYDRO _____	80
COAL _____	40
GEOTHERMAL _____	20
OIL & GAS _____	280
NUCLEAR _____	130
TOTAL 550	