indicate that industry has appreciably increased its share of total sales during the past decade.

It is essential, from Taipower's viewpoint, as well as from the viewpoint of the entire economy of Free China, that the load forecast be derived as correctly and scientifically as possible, taking into consideration all the applicable factors and trends.

The result of our 10-year load forecast, covering 1963-1972 may be summarized as follows:

1. **PEAK LOAD** for Taiwan is expected to increase to 2,315 MW in December 1972, which is about triple the actual peak load carried in December 1962. This represents an average annual cumulative increase of 11.6 percent.

2. **ENERGY REQUIREMENTS** is expected to reach 1,528 MW at the sending end in 1972. This represents an increase of 993 MW over the actual requirements in 1962 or an average annual cumulative increase of 11.0%.

3. **CAPABILITY** of the Taipower system will increase to 2,423.9 MW in December 1972 if the Long-range Power Development Program as of April 1963 is carried out satisfactorily. This is an increase of 1,637.0 MW over the system capability registered as of December 1962 or an average annual cumulative increase of 11.9 percent for the 10-year period 1963-1972.

4. **GROSS MARGIN** will be maintained positive after July 1969. In December 1972, the margin will be 4.5%. However, from 1964 through early part of 1969, the capability falls short and in December 1967 a shortage of 13% is expected.

To sum up, an 11.1% average annual increase rate has
3. Comparative study for the selection of the imported energy resources in various stages of development.
4. Setting out the guiding principles for formulation of power development program to best suit the interests of Taipower, its customers and the Nation as a whole.
5. Technical, financial and economic studies on individual projects for their proper evaluation.
6. Formulation of the power development program by selecting among technically and financially feasible projects in the light of adequacy and economy.
7. Periodic review of the program for extensions, amplification, refinement and/or revision as desirable or necessary.

The 1962 Taipower system was barely able to meet the system loads. To meet the load growth, it should be expanded. The needed expansion for the forthcoming decade (1962-72) is estimated to be 100 MW of firm power and 150 MW of dependable peaking capability per year in average plus a suitable system reserve. The Taipower development program during the coming decade should therefore achieve this purpose, with new generating capacity being brought into operation in advance of load requirement, whenever possible. Projects to be completed before 1975 should also be considered if they are started before 1972.

Taiwan is endowed with relatively rich hydro-electric potential. But coal reserve on the Island is very much limited and expansion of coal production is confronted with increasing difficulty. Crude oil reserve of any size has not been discovered in Taiwan. Natural gas has been found and been forecasted for 1963-1972, corresponding to 11,680 Gwh of energy sales for the year of 1972. While the existing power system was barely capable to meet the 1962 loads, it has to be expanded nearly three times in the coming decade so as to keep pace with the load growth.

How to satisfactorily meet this large block of soaring power demand at the lowest practicable costs is a challenging problem. Taipower attempts seeking of the optimum selection by joint efforts of engineers, economists, financial analysts and management. To meet this challenge, Taipower has developed a 10-year (1963-1972) master plan derived from the following steps:
1. Analyze the future energy requirements for Taiwan and establish realistic electric power forecasts.
2. Comprehensive survey of local energy resources to determine the availability, practicability and priority in their utilization.
After careful evaluation, eleven sites are selected for earlier development. The Tachien reservoir project on the Tachia River including extensions of Kukuan and Tienlun power stations has been thoroughly investigated. It is found to be technically and economically feasible.

These favorable sites listed above will be able to furnish about 1,246 MW of dependable peaking capability supported by 375 MW of firm power. These peaking developments together with thermal base-load plants will be suitable and adequate to meet the future load demand for the next two decades.

Coal for Power Generation

According to the results of successive survey, the total extractable coal reserve in Taiwan at the end of 1958 amounted to 209 million tons, including 109 million tons of fuel coal and 80 million tons of coking coal. 16 million tons have been mined since 1958, leaving only about 193 million tons at the end 1962. Coal fields are generally located in Northern Taiwan. Producing strata dip at steep angles and are extremely thin (0.25 to 1 m). The deepest mine sinks 2 km below the ground surface. Two-thirds of the reserves contain in seams less than 2 feet thick. At present, the annual coal production and consumption are equal, about 4.3 million tons. In 1969, the consumption is expected to increase gradually to 6 million tons, at this rate the known deposits will be depleted in about 30 years.

Coal mining is essentially a manual operation. Modern equipment may not pay because of the thin and discontinued beds. Labour and other mining expenses are increasing as easily accessible and relatively rich deposits are gradually depleting. Therefore, with the present rate of consumption, only 193 million tons of coal is available for a few years only. It is feared that the town will have to depend on imported coal in the near future. In fact, it is possible that the coal deposits may be exhausted before the latter part of this century.

Hydro-Electric Potential

Taipower has made comprehensive survey on hydro-electric potential in Taiwan. A total of 101 hydro sites have been located. The total technical potential was estimated to be 4,200 MW in installed capacity and 800 MW on continuous energy basis. As the peaking capability is high and firm power is low, hydro will be developed to supply system peak-load.
exhausted. It is estimated that coal price will increase probably at a rate of 2-4% annually. Meanwhile, the increase in production would not be able to match the increase in consumption. After 1964, the anticipated shortage of coal supply will be 100,000-700,000MT per year. This limits the extension of the extension of the coal-firing facilities.

Natural Gas and Oil

Preliminary information indicated relatively promising prospect for natural gas. Proven reserves at one field is estimated at 23 billion M³. Heat value of the gas is about 1,000 Btu per cubic feet under atmospheric pressure. We are planning to increase the productivity from the present daily capacity of 870,000 M³ to 1.7 million M³ in 1968. However, very little of this production will be available for power generation. One another field is reported to have possibly richer deposits than Chingsha. The results of exploration are being closely watched.

We now supplies 600,000 M³ natural gas daily to a fertilizer plant in Miaoli at 46 US cents per million Btu. The price is expected to drop to competitive level when more gas from new fields is available for power generation.

So far, crude oil is practically imported (99.8%) Known deposits are insignificant.

Imported Fuels

When locally available fuels are insufficient for needed power generation, fuel oil will first be imported and later may be followed by nuclear fuels.

Importation of large amount of fuel-oil for power generation will begin in 1966 upon completion of the 200 MN Shenao No. 3 unit. The imported quantity will increase with

$10.75
5.25
16.00
4.75
0.75
1.00
US$22.50

This is equivalent to 57 US cents per million Btu at heating value of 18,000 Btu per pound.

In Taiwan, nuclear plant will compete with conventional plant burning imported fuel-oil in not too distant future. Presently, plant investment and production costs are still considered to be higher than the conventional plant for most areas of the world. Progress made in recent years has cut both the construction and production costs by a substantial amount and will continue to decrease. With these trends continued, nuclear power will probably become directly competitive in cost with coal-fired plants in Taiwan in 1970 or 1972.

Construction cost for a 300 MW capacity nuclear power plant in Taiwan for initial operation in 1971 is estimated to be US$ 64,650,000.

According to the afore-mentioned appraisal of energy resources in Taiwan, the integrated Taipower system will continue to consist of two components: peak-load stations by hydro and base-load stations by thermal. This combination represents an economical utilization of both hydro and thermal capacity and is functionally suitable.

Basic considerations in selecting new projects for the 1963-72 program include adequacy, technical feasibility, financial
Yunnan hydro stations for facilitating peaking operation. The additional peaking capability will cost only US$75 per kw incremental. Shenao No. 3 (200 MW) is designed to burn local coal. It will cost US$160 per kw.

To meet the growing energy demand immediately after 1966, gas or oil-fired station is the only logical solution. If gas supply is adequate, the station will burn gas, otherwise the imported oil. Sive of the unit will be 300 M.

The Tachien reservoir project includes the Tachien reservoir to be created by a concrete arch dam 207 meter high, a power plant housing 8 units of 85 MW each, a supplemental diversion system, and the Kukuan and Tien Lun extensions. The annual power benefit is estimated at US$15.2 million and the annual power cost at US$11.6 million. Besides, there are irrigation and other benefits.

The first nuclear power unit will be completed in 1971 and will be for base-load operation. The second unit (to be completed in 1975) will probably be of similar design and will be installed at the same site for economy. It is expected that by 1971 or later, nuclear power will be cheaper than the conventional.

A number of alternative programs for comparison with the selected program to provide for the system peaking capability have been studied including the conventional thermal (Alternative A), the peak-load thermal (Alternative B) and the nuclear and the pumped storage combination (Alternative C). The following is a comparison of the annual costs:

<table>
<thead>
<tr>
<th>Annual Costs*</th>
<th>US$1 million</th>
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<tbody>
<tr>
<td>The selected program</td>
<td>11.6</td>
</tr>
<tr>
<td>Alternative (A)</td>
<td>15.2</td>
</tr>
<tr>
<td>Alternative (B)</td>
<td>19.1</td>
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<tr>
<td>Alternative (C)</td>
<td>14.9</td>
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</tbody>
</table>

Adequate power supply is a major responsibility of any power utility. Power curtailments in the recent years in Taiwan caused tremendous economic and financial damages not only during curtailment but also in the years followed. Accelerated development of power is mandatory for improvement of the situation in the future.

The target of the development program is an adequate but not extravagant, power supply at all times. System supply output under average hydrologic conditions be insufficient to meet the demand. Likewise, the system capability should be adequate to supply system peak load at all times. The system reserve capacity is preferably no less than 10 percent of the largest unit in the system, whichever is larger.

In the composite system, the additional output of the hydro component during wet seasons is useful not only for replacement of thermal output to save fuel, but also for compensating the thermal capacity shut down for scheduled maintenance. Therefore, in the system, independent standby units will not be necessary.

According to the basic considerations outlined above, the projects given below are selected to form the 10-year power development program:

In 1963, a new thermal unit (125 MW) was completed 4 days ago and Shihmen Hydro Plant (90 MW) will be completed in November 1963. Kukuan (90 MW) and Tien Lun (26 MW) extensions will be completed in 1964 at an incremental cost of US$55 per kw. The minor hydros will make use of the existing facilities and their average production cost will be less than 4 miles per kwh. Hydro improvement project includes provision of pondage for Wulai, Liwu and