Impacts of hydroelectric development on the environment

Concerned with increasing energy prices, balance of payment problems and reliability energy supplies, many countries are reassessing the role of hydroelectric energy within national energy policies. Since hydroelectric generation does not consume water, the projects – once developed – can be used to provide water for agricultural and industrial developments, two major problems faced by all developing countries. While the primary impacts of the majority of hydroelectric developments have been beneficial, it is now evident that they have also contributed to several adverse environmental effects. Two such major environmental impacts are discussed: problems due to erosion and sedimentation and implications of inundations, especially in terms of resettlement.

Keywords: Water power; Development; Environmental implications

Water power is not a new phenomenon: it has been used in one form or another for some 2000 years. Earlier attempts to harness energy from water were small-scale and for specific purposes only. The situation has dramatically changed during the past hundred years or so due to major scientific innovations and technological developments.

Hydropower developments were somewhat neglected in many countries during the 1960s, mainly because it was economically more advantageous to generate electricity by using oil, which was cheap and plentiful. Even though operating costs of hydropower plants are low, the capital costs are high, and accordingly more emphasis was placed on power plants operating with fossil fuels. The 1973/74 oil crisis started to change this situation. Increasing oil prices ended the era of cheap energy and forced most countries to explore alternative ways of generating electricity economically and to ensure supply reliability.

Since hydropower is the only renewable form of energy that can be used extensively in most countries for large-scale generation of electricity and can often be developed with indigenous expertise, it started to attract more attention in the 1970s. The dams and other structures built are also invariably used for other purposes such as irrigation, flood control, navigation, recreation and aquaculture, so that comprehensive water resources developments have become increasingly attractive for many countries.

Especially for developing countries, water resources developments could successfully contribute to the solution of two major crises facing them today – energy and food. Furthermore, if the construction processes are planned carefully so as to use extensive labour-intensive technology, they could provide employment for a large number of unskilled labourers – the main type of unemployed labour – for several years.[1,2]

Potential

According to the survey of energy resources presented at the World Energy Conference held in September 1980 in Munich, hydroelectric generation accounts for about 23% of total global electricity supply. This is an average figure, as for countries like Brazil, Canada, Moroco, Norway and Sri Lanka, hydropower currently accounts for 70–100% of all electricity generated.[3]

While hydropower potential has been exploited to a considerable extent in the advanced industrialized countries of North America and Europe, including the USSR, there is still a vast potential in many countries of Africa, Asia and Latin America which remains to be developed. Annual hydroelectric potentials for different regions of the world, as provided during the 1980 World Energy Conference, are shown in Table 1. During preparation for the UN Conference on New and Renewable Sources of Energy (UNCNRSE) held in Nairobi in August 1981,[4] it was felt that estimates provided for Asia may not include data from China. Currently the theoretical potential for China is estimated at 6×10^{12} kWh per annum, with a technically usable potential of 1.9×10^{12} kWh. At the end of 1979, the total operating potential was 0.05×10^{12} kWh per annum and potential under construction was 0.0517×10^{12} kWh per annum.[5]

Useful

With the present constantly changing energy price scenarios, and the fact that hydropower developments provide a useful form of indigenous energy, it is highly likely that more countries will encourage intensive development of their hydropower potentials. Estimated probable hydroelectric development during the period 1976–2020, as provided during the 1980 World Energy Conference, is shown in Table 2. It indicates that the total annual energy from installed hydroelectric facilities from all regions of the

Table 1. Annual hydroelectric potentials of different regions.[a]

Region	Theoretical potential	Technical usable potential	Operating potential	Potential under construction	Planned potential
Africa	10.118	3.14	0.151	0.047	0.201
America (North)	6.15	3.12	1.129	0.303	0.342
America (Latin)	5.67	3.78	0.299	0.355	0.809
Asia (excluding USSR)	16.486	5.34	0.465	0.080	0.368
Oceania	1.5	0.39	0.059	0.020	0.032
Europe	4.36	1.43	0.842	0.094	0.197
USSR	3.94	2.19	0.265	0.191	0.17 (estimated)
Total	44.28	19.39	3.207	1.090	2.12

[a]All figures in 10^{12} kWh.

Table 2. Estimated probable hydropower development, 1976–2020.

Country groupings	Potential energy in EJ (1 EJ = 10^{18} J) 1976	1985	2000	2020
OECD countries	3.78	4.49	5.37	7.80
Centrally planned countries	0.72	1.20	2.88	8.70
Developing countries	1.17	1.97	4.49	11.80
World total	5.67	7.66	12.74	28.30

world is likely to increase five-fold during these 44 years.

Environment and development

All development projects have economic, social and environmental consequences, which may be beneficial or adverse. Whether these consequences are acceptable to a country is often a matter of considerable controversy, and depends very much on the individuals concerned with the project – their economic status, level of education, interests, motives and biases. Thus certain developments may be unacceptable in some countries but acceptable in others. Even within a country, it is not unusual to find that a proposed water development project is unacceptable to a certain sector of society on account of anticipated adverse social and environmental effects, while another sector may for different reasons be lobbying intensively for the same project.

Controversies over construction of hydroelectric projects have been common in developed countries, but in recent years they have surfaced in developing countries as well. A current example is the Silent Valley development in the state of Kerala, which contains India's only substantial stretch of evergreen forest. The forest is 50 million years old and has evolved to become the sanctuary of unique plant and animal life. The valley is called 'silent' since for unexplained reasons the noisy cicada insect is absent. The home of rare species like the lion-tailed monkey, the project has fuelled a major controversy, with proponents ridiculing environmentalists for putting 'monkeys before man'.

The dam, if constructed, will add 60 MW to the state's current 1000 MW capacity, irrigate 10000 hectares of land in the backward region of Malabar, and provide employment for some 3000 people during construction. To some extent, this type of controversy can be resolved by a detailed cost–benefit analysis, which is seldom carried out for most projects. It is inevitable that any development project will benefit some more than others, and frequently some people may have to bear additional costs, both tangible (ie heavier tax liabilities) and intangible (ie social and environmental costs).

There are many environmental implications of hydro developments and the final impact often extends much further than the project area itself, making reliable analysis difficult. The interaction of diverse forces is often so complex that environmentalists are hard-pressed to predict overall effects with a high degree of confidence.

Planning

Unless planning precedes construction by 5–10 years, several unpredictable situations tend to develop, some beneficial and others adverse. Using currently available data, environmentalists often find it impossible to convince engineers, economists and politicians that certain developments are unwise, or of the necessity to spend scarce resources on appropriate remedial measures because of lack of hard facts or solid scientific evidence. Water development projects have traditionally been the domain of engineers, and social and environmental considerations have often been sadly neglected during the planning process. Social and environmental scientists have often been brought in only after the damage has become apparent. As a general rule, it is more expensive to rectify damage once it has been done and cheaper to take anticipatory remedial measures. Even though lip-service is given to interdisciplinary teamwork, it is not prevalent in most countries at present.

The environmental implications of hydropower developments are many, and it is not possible to discuss them all within a limited space. Two major environmental problems are discussed here – erosion and sedimentation, and problems due to inundation, especially resettlement.

Erosion and sedimentation

Hydroelectric energy is often referred to as a renewable source of energy. While this is conceptually correct, it could become a non-renewable source of energy in some cases, unless erosion problems in watersheds and sedimentation in reservoirs can be kept under control. There are cases where sedimentation has so reduced reservoir storage capacities, that hydroelectric generation has suffered substantial reduction.

Although the main purpose of a reservoir is to store water, it also stores sediment contained in the river water entering the reservoir. Reduction of flow velocity increases sedimentation, which influences the storage capacity of a reservoir and thus its useful life. The amount of sediment carried by a river is a direct function of type, size and nature of its watershed and the land-use pattern thereon, and on the velocity and turbulence of the flow.

Since sedimentation rate depends on the silt content of river water, some reservoirs need special planning and management, if the silt contents of the rivers concerned are high, and if the design life of reservoirs needs to be maintained. The yearly average silt contents of some major rivers are as follows:

Yellow River (middle reaches)	37.6 kg/m^3
Colorado River	16.6 kg/m^3
Amur River	2.3 kg/m^3
Nile River	1.6 kg/m^3
Yangtse River	0.4 kg/m^3

The Yellow River in China passes through an extensive loess plateau, which has serious soil erosion problems, and therefore sedimentation is a major problem. Each year it carries 1.2 billion tonnes of silt to the sea, and deposits 0.4 billion tonnes on its own channel bed. At this high rate of sedimentation, the river bed has now become higher than the surrounding areas and the banks are protected by dykes, which have to be raised every year. The build-up of delta amounts to some 20 km^2 every year. Some of the tributaries of the Yellow River carry an extraordinary amount of silt (the average annual silt content of the Jing and Wuding Rivers are 172 kg/m^3 and 136 kg/m^3 respectively).

Sanmenxia

The complex problem of sedimentation in reservoirs and their impacts on electricity generation can be best illustrated by considering the case of the Sanmenxia Reservoir, located on the lower part of the middle reaches of the Yellow River. The multipurpose hydropower project controlled a catchment area of 684000 km^2, which is nearly 92% of the entire Yellow River Basin. The construction of the 96 m high and 908 m long concrete gravity dam was completed in September 1960.

The yearly average sediment load at Sanmenxia is about 1.6 billion tons; 86% of which occurs during the July to October flood season. The maximum sediment concentration observed has been 900 kg/m^3 in 1977.

When the reservoir filling started in September 1960, the storage capacity was 9.62×10^9 m^3. Within 18 months, the reservoir capacity was reduced to 7.87×10^9 m^3 due to excessive sedimentation, and by June 1966, the available capacity of 5.90×10^9 m^3 was an even more acute problem. Hydropower generation also suffered and by 1964, the reservoir was generating less than 25% of its original capacity in 1960.

The design, operation and management of the system had to be radically changed, initially to flush as much sediment as possible from the reservoir and then to prevent further rapid siltation. Much of the silt is deposited during July to October, when sluices are opened to flush sediments downstream. Most of the electricity is presently generated during November to June. Four penstocks previously used for electricity generation had to be modified to discharge flood water. Some of the turbines originally installed have now been moved to other sites, and the dam currently generates significantly less electricity than it could during the earliest years of its operation.[6]

Erosion and sedimentation have also been a major environmental problem for the Aswan Dam in Egypt. The dam, one of the largest in the world, was completed in 1968. Before construction, large amounts of silt were either deposited on the Nile Valley or carried all the way to the Mediterranean. These sediments are now being trapped in the reservoir created by the dam. Before the dam, suspended matter in the River Nile, passing the Aswan, ranged between 100 million tonnes/yr to 150 million tonnes/yr. Observations made during the first few years after the completion of the dam indicate that the reservoir is losing about 60 million m^3 of storage per year due to siltation. At this rate, the dead storage capacity of 30 km^3 will be filled in about 500 years.[7]

As a result of the siltation in the reservoir, clean water is now flowing downstream of the dam causing erosion of the river bed and banks. Attempts are now being made to rectify the situation.

Silt

Another effect of siltation in the reservoir is the erosion of the Nile Delta, some 1000 km away. Prior to the construction of the dam, the Delta used to be built up during the flood season, with the silt carried by the river to the Mediterranean. This situation in the Delta compensated for the erosion that resulted from the winter waves of the preceding year. Without sufficient siltation, erosion of the Delta has become a major problem, and studies are now being carried out to find a suitable solution.

Loss of silt has further affected the productive capacity of the Nile Valley which used to get a regular deposit of sediments every year. Currently studies are being undertaken to assess the actual nutritive value of the silt, and the trace elements present therein, so that this loss can be compensated by using chemical fertilisers. Before the dam was constructed, the silt load carried by the Nile was estimated at 134 million tonnes/yr (based on 30 years of available data), of which 125 million tonnes was accounted for by the flood season. Only 12% of this, 16 million tonnes, was deposited on land, and the rest used to flow with the water to the sea. After the dam was constructed, suspended sediment now being deposited on land is estimated at 4 million tonnes, giving rise to a short-fall of 12 million tonnes/yr. It has been suggested that the loss of the nitrogenous component of silt can be counter-balanced in the cultivated lands by some 13000 tonnes of lime nitrate.[8]

Lack of downstream sediment significantly reduced the planktons and organic carbons, which, in turn, reduced the sardine, scombroid and crustacean population of the area. Loss of sardine along the Eastern Mediterranean has created economic problems for the fishermen. Furthermore, there was a thriving small-scale industry on making bricks from the silt dredged from the canals. Without this silt, many such industries have now resorted to using the topsoil near the canals to make bricks, thus contributing further to the loss of productive soil in the country. On the positive side, however, lack of silt has reduced the cost of dredging canals.

Erosion and sedimentation processes are often accelerated due to the construction activities themselves. If the dams constructed are either rockfill or earthfill, large volumes of rock and earth have to be excavated. To reduce transport costs, quarries and borrow pits are often located near dam sites. Large-scale excavation to obtain such materials not only leaves unsightly scars on the landscape but also increases soil erosion and disturbs wildlife. These impacts could be quite severe if large volumes of earth and rock are necessary and if the activities are confined within a somewhat limited space.

Other building

Thus, for the construction of the LG 2 Dam of the James Bay project, which required about 150×10^6 m^3 of fill, and Wreck Cove Project in Nova Scotia, Canada, where construction activity was confined to a small area, serious environmental problems were encountered.

Since dams are mostly constructed in remote areas, often new roads must be built which causes removal of both vegetation and topsoil. The rate of soil erosion significantly increases due to such activities and also from the presence of many large quarries and borrow pits. This in turn increases the sediment load carried by rivers, most of which then gets deposited in the reservoirs, and thus reduces their storage capacities. In certain cases (as in the Tarabela Dam in Pakistan) the situation becomes serious, and countermeasures are essential. Thus, it is necessary to ensure that construction activities are carried out within strict environmental protection guidelines.

Currently the average annual storage loss in the USA is 3.5% for small reservoirs having capacity of less than 10000 m^3. The storage losses decrease with the increase in storage capacity of reservoirs, and amount to only 0.16% for capacities greater than 10^9 m^3.[9] The storage capacity of the Bassano Dam on the Bow River in Alberta, Canada, was reduced from 34×10^6 m^3 in 1911 to 11×10^6 m^3 in 1970. For 19 reservoirs in Central Europe, having storage capacities ranging from 1.5×10^5 m^3 to 0.23×10^6 m^3, storage depletion was 0.51% per annum.[10]

From an economic viewpoint, the cost of siltation and sedimentation in rivers and reservoirs is quite substantial. It has been estimated that for the USA alone, some 376×10^6 m^3 of sediments are dredged every year from water bodies at annual costs of more than $300 million. Reduction of economic lives of man-made lakes further cost that nation $60 million annually.[11]

Problems due to inundation

Problems due to inundation can be of three principal types – impacts on land, including historical monuments, on animals and man.

Lands flooded due to hydropower developments are often forest areas. In many instances timber has to be harvested before flooding commences. The final decision as to whether or not to harvest the timber depends not only on its value but also, more importantly, on the type of use of the reservoirs. For example if a reservoir is to be used for boating, the timber has to be harvested even if it could not be marketed.

For the James Bay project in Canada, the general policy was to clear the areas where there could be intensive fishing and also from those parts that are visible from the roads and in the mouth of the tributaries. In cold temperatures, as prevailing in most Canadian waters, fully submerged trees could last a long time. For example, tree trunks in the Gounin Reservoir show very little deterioration after being flooded for some 55 years.

Historic monuments

In certain areas flooding could affect important historical monuments or archaeological sites. The best known case is the Aswan Dam which inundated areas that were thinly populated but rich in historical monuments. The magnificent temples of Abu Simbel and Philae (near Aswan) had to be dismantled and moved to higher locations. The international undertakings to save such historical treasures were both complex and expensive.

While very few dams constructed have affected such important historical monuments, many do threaten archaeological sites. What is important is to ensure competent archaeological surveys are carried out before inundation takes place. Even in an advanced country like the USA, where environmental awareness is at a much higher level than most other countries, many early rock paintings and petroglyphs have been already lost due to the construction of dams.

Animal life is endangered since flooding can inundate large areas of animal habitat. For large African dams like the Volta, major rescue operations had to be undertaken to catch and relocate as many animals as possible. For large animals like elephants, giraffes or rhinoceroses, such operations are difficult and expensive. Similarly some attempts were made to relocate beavers affected by the James Bay project. Relocation efforts are especially important when rare or endangered species are involved.

When unique and very rare habitats are to be flooded, it may be necessary to change the design of the structures or consider construction in a different location. In certain cases, suitable alternatives may not be available and the projects need to be reconsidered or even stopped, if species concerned are unique.

The most important impact of inundation in many cases is on the effect on people living in the area. Resettlement of people should be an integral part of any hydropower development policy, but unfortunately it is not considered in the same detail as civil and electrical problems. Thus, many major water development projects have contributed to major social dislocations.

For example, the Volta Dam in Ghana has inundated an area of about 3275 square miles, and the resulting lake has a shoreline of over 4000 miles. As a result of the development, some 78000 people and more than 170000 domestic animals had to be evacuated from over 700 towns and villages of different sizes. Eventually, 52 new settlements were developed to house 69149 people from 12789 families.

Social problems

This created a major social problem since a large number of people coming from small villages (600 of the 700 original villages had less than 100 people, and only one had a population of over 4000), with different ethnic backgrounds, languages, traditions, religions, social values, and cultures, had to be resettled into only 52 locations. The complex emotional relationships between the different tribes and their lands were not properly understood. There were many who found it very hard to make a clean break with their ancestral roots, by leaving their gods, shrines and graves of ancestors. The development of a socially cohesive and integrated community, having a viable institutional infrastructure, was hard to achieve.

The economic stability of the settlers depended on agricultural products from family farming plots. Unfortunately land clearing schemes did not progress on schedule, and in some cases cleared areas were not ready for farming when the settlers arrived. The World Food Programme had to step in

Table 3. Resettlement of people due to various dams.

Dams (dates reservoirs filled)	Number relocated (approx.)	Countries involved
Aswan (1968)	120000	Egypt and Sudan
Bkakra (1963)	36000	India
Brokopondo (1971)	5000	Surinam
Damodar (4 projects, 1959)	93000	India
Gandhi Sagar	52000	India
Kainji (1969)	42000–50000	Nigeria
Kariba (1963)	50000–57000	Zambia and Zimbabwe
Keban	30000	Turkey
Kossou (1971)	75000	Ivory Coast
Lam Pao	30000	Thailand
11 projects (1963–1971)	130000	Thailand
Nam Ngum (1971)	3000	Laos
Nam Pong (1965)	25000–30000	Thailand
Nanela (1967)	90000	Pakistan
Netzahualcóyotl (1964)	3000	Mexico
Sanmenxia (1960)	870000	China
Pa Mong (projected)	310000–480000	Thailand/Laos
Tarbela (1974)	86000	Pakistan
TVA (ca. 20 dams 1930s-present)	60000	USA
Upper Pampanga (1973)	14000	Philippines
Volta (1965)	80000–84000	Ghana

to avoid a major catastrophe.

Similarly, the Kariba Dam on the Zambesi River displaced approximately 57000 Tonga tribesmen. The resettlement programme for the Tonga tribesmen left much to be desired since many of the planners were from outside Africa. Not only did the tribesmen suffer great cultural shocks when being thrust into totally different communities but it also took two years to clear sufficient land to meet their subsistence needs. The government had to step in to avert famine and very serious hardships, and, ironically, this well-intentioned step became one of the most destructive parts of the process. The food distribution centres became transmission sites for sleeping sickness.

Relocation

Inundation due to the Danjiangkau Reservoir in China displaced 320000 people. The relocation cost was 200 million yuan, but this figure is somewhat misleading since overall labour costs during the Cultural Revolution were negligible. Currently plans are being made to increase the height of the Danjiangkau Dam, which would require relocation of some 250000 additional people. With the present system and costs, the relocation cost is expected to be about 500 million yuan. Some 870000 people had to be resettled due to the Sanmenxia Dam.

Similar consequences have been observed from other water development projects. Approximately 100000 people had to be relocated due to the Aswan High Dam, without sufficient planning, and the World Food Programme had to rush in famine relief for the Nubians. Other examples of the number of people that have had to be resettled due to dam construction in different parts of the world are shown in Table 3.

Population resettlement due to water development projects in many developing countries has not been a satisfactory experience. Inadequate planning, insufficient budgets, incomplete execution of plans and little experience of the problems of technology transfer have all contributed to this failure. The fact that many of the people to be resettled were rural and illiterate, and thus had very little political power, did not help.

The direct beneficiaries of the projects were often the educated elites, who controlled the power structure, whereas direct social costs were mostly incurred by the rural power having no political power base. It is unfortunate that in nearly all cases the nature of benefits are emphasized, but *not* the nature of the beneficiaries.

Conclusion

There is no doubt that the primary impacts of the vast majority of hydroelectric development projects have been beneficial. Equally, however, there is no doubt that many of these projects have contributed to unnecessary, and sometimes unanticipated, adverse environmental and social disruptions, many of which could have been avoided, or at least significantly reduced in magnitude, if appropriate countermeasures were taken at the beginning. Unless environmental considerations are explicitly considered in the planning and implementation phases of these projects, such adverse impacts will continue to occur.

From the experiences of recent decades, it is clear that environment and development are two sides of the same coin, a fact that has not been realised by many. The old concept of environment *versus* development was incorrect, one must understand their complementarity of objectives.

In the future, we face the challenging and daunting task of meeting the basic human needs of the world. This is not going to be easy, but it will never be accomplished unless environmental factors and constraints are incorporated in the development projects. Only then can the benefits accruing from the projects be maximized, and the projects themselves can be sustainable over the long term. Hydropower developments are no exception.

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Hydroelectric power in China

China's energy shortages are a major problem for its industrial and agricultural modernization programme. Coal-fired power stations are rapidly being built to help the problem in the short-term, but in the long-term China intends to make use of its vast resources of hydropower. The authors present a summary of the state-of-the-art of hydropower in China.

Keywords: Electricity; Hydropower; China

The growth of electrical power production has been rapid since the People's Republic of China was established in 1949. During the period to 1981 the amount of electrical energy produced increased more than 60-fold and was achieved with a 30-fold increase in installed capacity. The installed capacity is now about 60 GW, in thermal and hydro-power stations of all sizes, with annual energy production in excess of 300 TWh. At present, the primary energy resources used in electricity production are coal (65%), hydropower (28%) and oil (7%).

Some 75% of Chinese electrical power is used by industry, about 15% by agriculture and the remaining 10% by transport, domestic and commercial users.[1] It is believed that there is a current shortfall of around 15% to 20% in power production[2] which is increasing as coal and oil production fail to keep pace with demand.

The shortage of electricity is much in evidence in many parts of China. Blackouts, rationing between industries and short working weeks are common in the major industrial centres. Until recently the major steel complex at Wuhan was virtually idle until the completion of the 600 km, 500 kV transmission line from Yaomeng coal-fired power station in the Pingdingshan coal field.[3] A recent report indicates that the Beijing–Tianjin–Tangshan power system, the largest integrated system in China, has a *load factor* of 93%.[4]

To meet the shortfall, the Chinese authorities are rapidly building thermal and hydropower stations of all sizes. In the meantime, China is stressing energy conservation measures[5] to save some of the 20 to 30 TWh of electricity wasted annually.[6] In addition it was reported that the plan to buy two 920 MW nuclear power stations from France, cancelled in July 1979, had been reconsidered in December 1980.[7] Six nuclear stations are now under consideration including one in Guangdong, as a joint venture with Hong Kong.[8] European collaboration may be sought in the exploitation of radioactive minerals.[9]

Hydropower potential

China's rivers have a total hydropower capacity of 680 GW and an annual generation potential of 6000 TWh according to the most recent national survey conducted during 1977–80.[10] Of this, some 370 GW is considered exploitable and if fully utilized would make China the world's leading user of hydropower.

By 1980, however, China had installed little more than 17 GW of plant which generated 48 TWh in 1979.[11]

The distribution of hydropower resources is largely determined by the terrain. West China is highland, much of it backing on to the Tibetan plateau, whilst the east is relatively low. The major rivers, which run from west to east, have their sources in the highlands and this, together with the heavier rainfall in the south, gives South-West China (Sichuan, Yunnan, Guizhou and Tibet) about 70% of the country's water power potential. The distribution of these resources is given in Table 1.

Major hydropower installations

The Chang Jiang (Yangtse) and Huanghe (Yellow) river systems have been, in the past, and will continue to be, in the foreseeable future, the most important rivers as far as hydropower generation is concerned. The construction of major installations, those with installed capacities greater than 250 MW, has played the most important part in hydropower development. Some 20 such schemes account for 55% of the installed capacity and of these four projects are on the Huanghe and eight on the Chang Jiang.[12]

China's first large hydropower schemes were constructed in the north-east between 1937 and 1945 during the Japanese occupation. The Supung power station (Liaoning) with 300 MW installed capacity was completed in 1944 and the Dafengmen (Jilin) with a capacity of 564 MW in 1945. Much of the equipment was removed to the USSR, at the end of the war with Japan, and not restored until 1959.[13] No new major stations were planned until large scale intervention to regulate the Huanghe was proposed in 1955.[14] The plan included power production amongst other measures concerned with flood control, navigation and irrigation.