

# Hydropower and Sustainable Development in China



## 中国水电开发与可持续发展

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# 1. 中国的经济发展对电力的需求

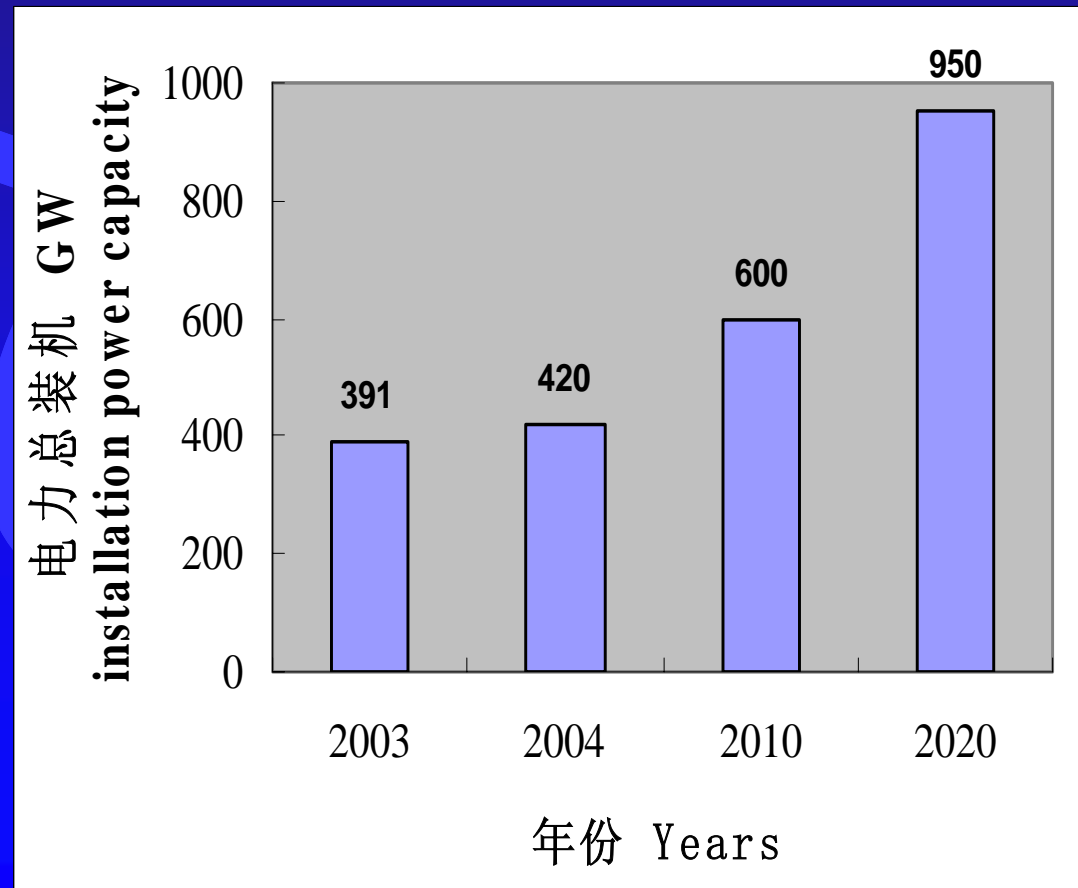
## Power Demand from China's Economic Development

目前中国正处在经济高速增长的时期，国民经济的增长必然伴随着对能源电力需求的增长。

At present, China is in a period with high-rate economic growth. The national economic growth is necessarily accompanied with an increasing demand for energy and electric power.

全国电力总装机增长前景图

increasing prospect of installation power capacity



## 2. 中国一次能源储量及评价

### China's Primary Energy Reserves and the Assessment

- 中国的电力主要依靠常规一次能源获得。

Electric power in China mainly depends on traditional primary energy.

- 据勘查统计资料:

煤炭储量  $1390 \times 10^8$  吨 (备产储量)

原油储量  $33 \times 10^8$  吨

天然气储量  $1.7 \times 10^{12}$  立方米

水能 (可开发的) 储量  $24740 \times 10^8$  kW·h/年

Here is the statistic data from survey:

Coal reserves (developable):  $1390 \times 10^8$  tons

Crude oil reserves:  $33 \times 10^8$  tons

## 2.1 煤炭 ( Coal )

- 煤炭是我国电力的主要能源，其年产量的50%以上用于发电，煤电占全国电力的74%左右，是中国的主力电源。但大量燃烧煤炭造成的环境污染问题是难以克服的。

Coal is the major energy source for electric power in our country, with 50% of the annual coal output used for power generation. The coal-fired generation makes up 74% of the total power generation of the country, so it is the main power source in China. However the issues of environmental pollution caused by coal combustion can hardly be resolved.

- 要推广洁净煤的使用，提高煤电的燃烧技术，以提高煤炭的利用效率。

We should promote the utilization of clean coal, improve the combustion technology in coal-fired generation, and raise the utilization efficiency of coal.

- 煤炭是不可再生的，总储量肯定逐步减少。

Coal is not a renewable energy source and its total reserves will decrease year by year.

## 2.2 石油 ( Petroleum )

- 石油是中国紧缺的能源资源，人均占有量只是世界人均占有量的10.7%。

Petroleum is in shortage in China as an energy source with per capita quantity only accounting for 10.7% of that in the world.

- 石油是可携带能源，不宜大量地用于发电。

Petroleum is one kind of portable energy sources. It is improper to use plenty of petroleum for power generation.



## 2.3 天然气 ( Natural gas )

- 天然气也是中国的紧缺能源，人均占有量只是世界人均占有量的5%。

Natural gas is also in short supply in China with per capita quantity accounting for 5% of that in the world.

- 天然气主要用于化学工业原料及居民生活用能源。也不宜大量地用于发电。

Natural gas is mainly used as chemical raw material and domestic energy. It is improper to use plenty of natural gas for power generation either.

## 2.4 水能资源 ( Water resource )

- 水能资源在中国相对较为丰富，人均占有量为世界人均占有量的55.1%。

Water resource is relatively abundant in China with per capita quantity taking up 55.1% of that in the world.

- 它既是清洁的能源又是可再生能源，是用于发电的优质能源。世界各国无不优先开发水能资源。

Water resource is a clean and renewable energy, as well as a superior energy source for power generation. Most countries in the world give high priority to the development of water energy.

- 中国当前的水电装机容量约占全国电力的24%，年发电量占14.8%。

In China, the hydropower installed capacity accounts for about 24% of the total power capacity with an annual electricity generation making up 14.8% of the total.

- 水电开发过程必须建立一套科学、完整的评估体系，以作出准确的决择和采取相应对策。

A scientific and complete assessment system must be established in the process of hydropower development, so as to make right decisions and take proper countermeasures.

## 2.5 核电 ( Nuclear power )

- 核电是优质高效的能源。

Nuclear power is a superior and high-efficiency energy source.

- 经过几十年的发展，核电不论从技术上和安全上都已得到公众的认可。

Through several decades of development, nuclear power has been recognized by the public in terms of both technology and safety.

- 中国的核电事业起步较晚，应在近期大力发展核电，预期到2020年达到3600万kW的装机容量。

## 2.6 其它能源 ( Other energy sources )

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- 风能、太阳能、生物能等是洁净的可再生能源，应该加快科技研发和利用，以替代部分能源。

Wind, solar and biomass energy are clean and renewable energy sources. We should speed up scientific R&D and utilization in this respect to substitute these for part of other energy sources.

### 3. 中国的水电开发及现状

## Hydropower Development and Current Situation in China

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中国拥有众多的河流，是世界上水能资源总量最多的国家，这是中国经济发展重要而可贵的资源。

China is in possession of a lot of rivers and has the largest quantity of water energy source in the world, which is an important and precious resource for the economic development in China.

### 3.1 中国的水能资源情况

#### The status of water energy source in China

水能资源理论蕴藏量	6.88亿千瓦	Theoretical reserve of water resource	688 GW
年发电量	5.92万亿度	Annual electricity generation	5920 billion kWh
可开发利用的水能资源量	4.48亿千瓦	Water energy (developable) reserves	448 GW
年发电量	2.47万亿度	Annual electricity generation	2470 billion kWh
相当于每年燃烧煤炭	9.0亿吨	Equivalence of annual coal combustion	0.9 billion tons

## 3.2 中国的水电开发情况

### The status of hydropower development in China

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- 中国在1912年就拥有了第一座水电站，但水电开发利用真正起步于二十世纪的后半期。

Although China built up its first hydropower station in 1912, the actual development and utilization of hydropower started in the later half of the twentieth century due to the delay of industrialization process.



- 到2003年底全国水电总装机已达9217万kW，约占全国电力的24%，年发电量2830亿kW·h，约占全国发电量的14.8%。

The hydropower installed capacity in China reached 92.17GW by the end of 2003, making up 24% of the total electric power, with an annual generation of 283 billion kWh, accounting for about 14.8% of the country's total.

- 从水能资源的储量看，中国水电开发水平远低于世界上水能资源相对丰富的国家。

It can be seen from the reserves of water energy that the development level of China in hydropower is far behind those countries with relatively rich water resources.

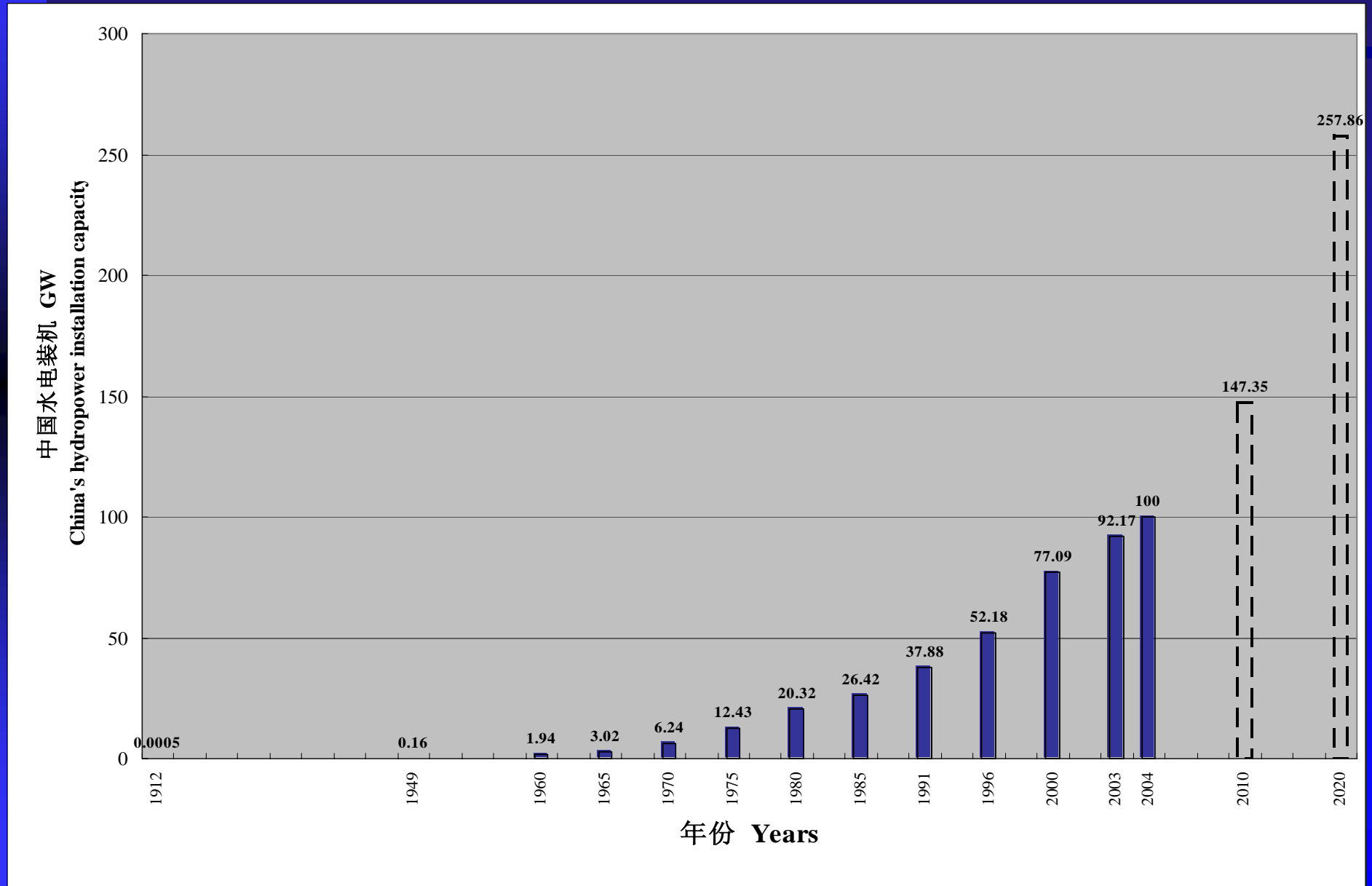
表1 世界各国水能开发情况

Table 1 Development status of different nations in the world

国家 Nation	可开发的总出力 Total reserve developable (GW)	已开发容量 Developed capacity (GW)	开发百分比 Development ratio (%)	数据年 Year of data
中国 China	448.00	100.00	22.3	2004
美国 USA	194.30	84.15	43.3	1986
加拿大 Canada	152.90	65.67	42.9	1997
巴西 Brazil	213.00	54.51	25.6	1997
俄罗斯 Russia	269.00	62.14	23.1	1986
印度 India	84.00	22.01	26.2	1997
日本 Japan	35.15	33.39	95.0	1986
法国 France	22.80	21.00	92.1	1986
挪威 Norway	38.00	26.00	68.4	1997
意大利 Italy	19.20	17.86	93.0	1986
西班牙 Spain	29.22	18.00	61.6	1997

表2 中国的水电开发历程及未来预期

Table 2 History and future prediction of hydropower development in China



### 3.3 中国的小水电发展

#### Development of small hydropower stations in China

- 中国拥有单站5万kW以下的小水电站约40,000余座，装机容量约2800万kW，占全国水电总容量的29%。

China has about 40000 small hydropower stations with an installation capacity below 50MW each, accounting for 29% of total hydropower capacity.

■ 小水电资源丰富，为解决广大农村和偏远山区等大电网难以播及的地区用电起到了积极而有效的作用；代替了一部分燃煤电源，保护了环境；小水电筹资容易，技术和设备相对简单，建设周期短，是不可忽视的可再生能源。

There are abundant small hydropower resources, which can play an active and effective role in power supply to the rural and remote mountainous regions that power grids can hardly cover, and are also favorable to environmental protection by replacing part of coal-fired energy. Small hydropower stations can be invested in a decentralized way. Thus the advantages of easy financing, relatively less-sophisticated technology and equipment and short construction period make small hydropower part of renewable energy sources that should not be neglected.

## 3.4 中国的大中型水电发展

### Development of medium and large-sized hydropower stations in China

- 单站5万kW以上的大中型水电站是中国水电的主力，经过五十余年的开发建设，已建成230余座，其中百万kW级以上的水电站25座，五十万kW级以上的40余座。

The medium and large-sized hydropower stations with the installation capacity above 50MW constitute the main proportion of the hydropower in China. Through more than 50 years' construction and development, over 230 stations of such scale have been set up, among which 25 stations are above 1000MW and 40 stations are above 500MW.

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- 大中型水电的发展奠定了我国水电开发领域的勘探、科研、设计、施工的各类人才、专业队伍、规范标准、组织型式、工程技术的完整基础，中国已有能力开发各类水电站。

These medium- and large- sized stations demonstrate that China has the capability to build all types of hydropower stations, and have laid down a sound basis in professional personnel and teams specialized in survey, scientific researches, design and construction, as well as in specifications and standards, organizational structure and technologies.

- 长江三峡水电站的建设成功标志着我国特大型水电站的开发建设能力上升到新的高度，当前是中国水电开发建设的最好时机。

The successful construction of Yangtze Three Gorges Hydropower Station has symbolized that China's development ability of super-huge hydro stations has reached a new high level, being among the front rank in the world. So it can be said that the best opportunity for China to develop hydropower industry is coming now.



## 4. 中国水电开发的经验与教训

### Experiences and Lessons in China's Development of Hydropower Industry

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积累了五十余年的实践经历，中国水电开发有着丰富的成功经验，也有可贵的失败教训。

From over 50 years' history, China has accumulated rich experiences in successful hydropower development and also learnt a lot of valuable lessons from failures.

#### **4.1 要有一个良好的建设管理体制。**

**There should have a well-established construction management system.**

#### **4.2 要做好流域和项目规划。**

**It's important to make a good planning for river basin and project.**

#### **4.3 要有一个优质的设计和技术管理。**

**There should have a good quality design and technical management.**

#### **4.4 要有完善的移民政策和行动。**

**There should have a sound resettlement policy and action.**

#### **4.5 要充分做好生态和环境的评估。**

**A thorough ecologic and environmental assessment must be done.**

**4.6 做好资金的筹措，多渠道融资，运作好资金，保证工程建设的资金使用。**

**A good multi-channel financing and fund operating is the guarantee of funds for project construction.**

**4.7 推行流域滚动开发机制。**

**A rolling development mechanism for a river basin should be set up.**

## 5. 长江三峡工程的范例

### An Example ---Yangtze Three Gorges Project

- 长江三峡工程是当今世界规模最大的水电工程，具有防洪、发电和通航等综合效益。

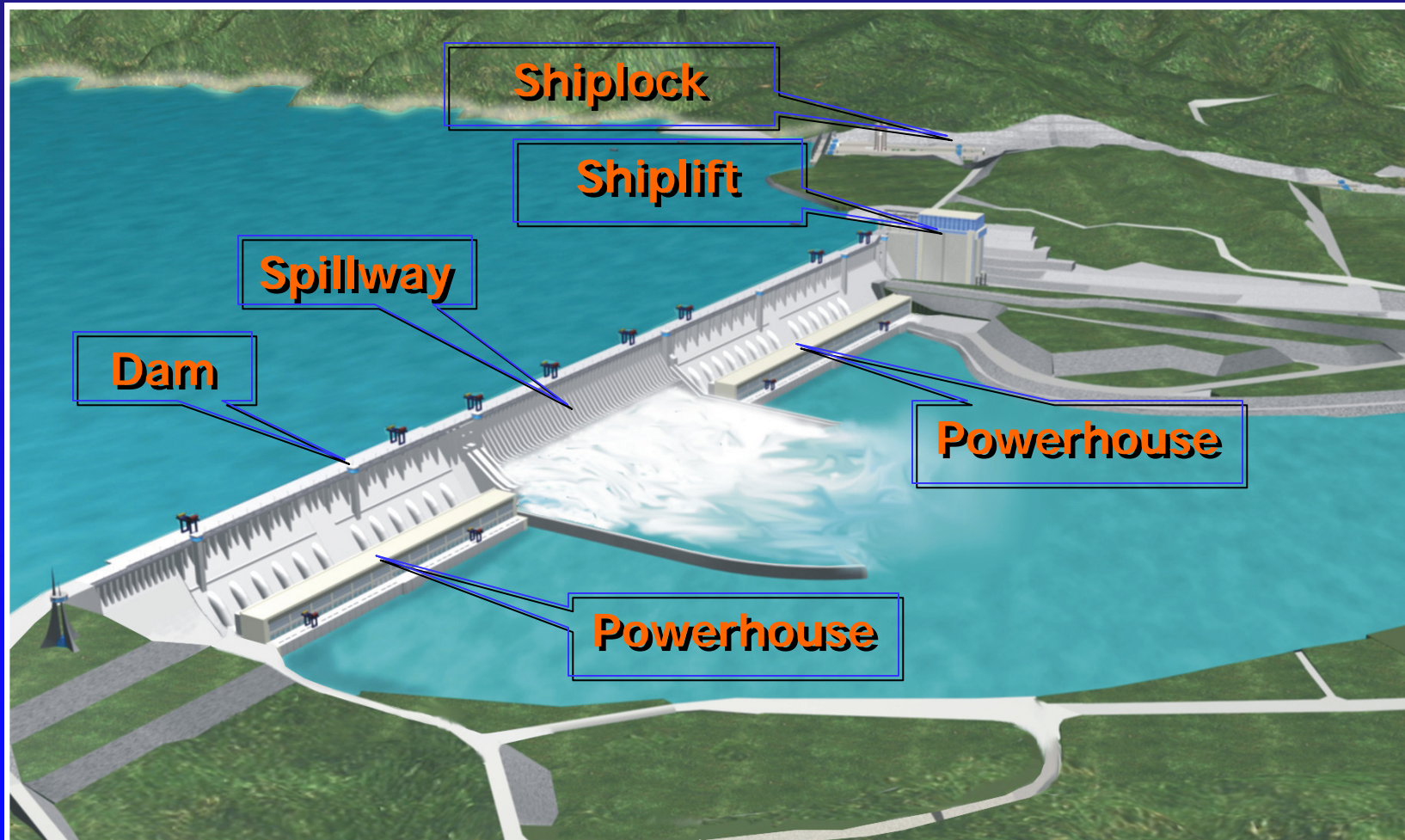
The Yangtze Three Gorges Project (**TGP**) is the largest hydropower project in the world at present. TGP has comprehensive benefits in flood prevention, power generation and navigation improvement on the Yangtze River.

## ■ 三峡工程有关指标

### Related indexes about TGP

总装机容量	1820万千瓦	Installation capacity	18200 MW
多年平均发电量	847亿度	Annual average generation	84.7 billion kWh
相当于每年燃烧煤炭	4000万吨	Equivalence of annual coal combustion	40 million tons
工程静态总投资	900.9亿人民币	Total static investment of the project	90.09 billion RMB
水库移民总量	113万	Total resettlement population	1.13 million
上网电价	0.25元/度	Grid tariff for hydropower	0.25RMB per kWh

- 三峡工程总体布置图  
General Layout of TGP



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- 三峡工程经历了七十多年的设想、规划、勘测、设计、论证、决策的全过程，于1992年由全国人大表决兴建。

Going through more than 70 years' course from initial envisage through planning, investigation, design, verification and decision-making, TGP was eventually left off ground via voting by the National People's Congress (**NPC**) in 1992.



# 1992年4月3日全国人大通过修建三峡工程的决议 NPC Approved TGP on April 3,1992



# 三峡工程静态总投资（1993年5月价格水平） Total static investment of TGP (1993-May value)



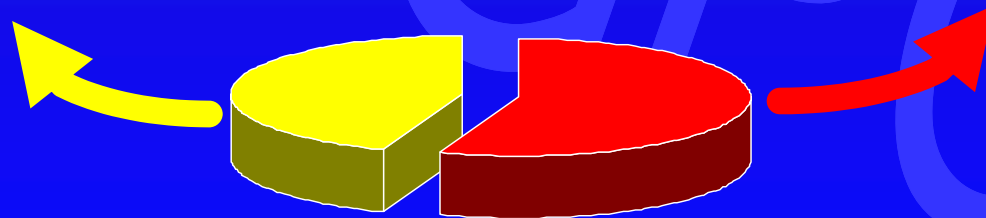
移民: 400亿元 人民币

Resettlement: 40.00 billion RMB



枢纽工程: 500.9亿元 人民币

Project: 50.09 billion RMB



静态总投资: 900.9亿元 人民币

Total static investment: 90.09 billion RMB

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- 整个工程建设期达17年，考虑到17年期间的物价因素和银行利率变化的因素，1994年预测工程所需总投资为2039亿元人民币（相当于250亿美元）。

The whole construction period lasts up to 17 years. Taking into account of price factor and interest rate change of banks during this long period, it was predicted in 1994 that the total investment of the project would be RMB 203.9 billion (equivalent to USD 25 billion).

- 中国政府决定运用市场经济的规律组织三峡工程的建设，成立了中国长江三峡工程开发总公司，作为三峡工程的项目法人，实行项目法人负责制。从1993年开始三峡工程进入实施阶段。

The Chinese government decided to use market economic rules to organize the construction of TGP and established China Yangtze Three Gorges Project Corporation (**CTGPC**) as the legal entity of TGP to implement the project legal entity responsibility system. Beginning from 1993, TGP has entered its implementation phase.

- 国家设立了三峡工程建设基金，以资本金的形式注入三峡总公司，三峡基金约占总投资的40%，三峡总公司自身发电收益投入约占20%，其余的40%资金由三峡总公司从融资市场获得即银行贷款、向社会发行债券、改制上市等多渠道筹措资金。

TGP Construction Fund was set up for injecting capital into CTGPC. The Fund covers about 40% of the total investment, while the revenue from power generation will cover 20% and the remaining 40% of capital will be raised from financial market through multi channels, such as bank loans, public issuance of enterprise bonds and corporate listing after restructuring etc.

■ 三峡工程经过11年的建设，已于2003年6月实现了水库的初期蓄水、船闸通航和首批机组发电的阶段性目标，水库移民已完成90万人口的搬迁。至2004年8月已有10台70万kW的机组投产发电，三峡电厂的总出力已达700万kW，自投产以来的发电量已达320亿kW·h。

After 11 years' construction, we realized phase objectives like initial impoundment of the reservoir, opening to navigation of the ship lock and power generation of the first batch of units in June 2003 and the relocation of 0.9 million reservoir residents. Up to August 2004, ten hydro turbine-generator units each with a capacity of 700 MW have been put into operation in the Three Gorges Power Plant with the total output reaching 7 GW and the total electricity production is up to 32 billion kWh.

# 今日之三峡工程 Today's TGP



# 水库初期蓄水 Preliminary Impoundment





泄洪

Flood Discharge



# 机组发电 Power Generation



# 双线五级船闸通航 Ship lock Navigation



# 三峡工程第三阶段工程施工 The Phase-3 Project Construction



■ 截至2003年底，三峡工程投资已实际完成1000亿元人民币。现在再预测到2009年全部竣工时，工程总投资大约可控制在1800亿元人民币（约220亿美元）以内，没有突破预算，略有结余。

By the end of 2003, RMB 100 billion of investment has been fulfilled for TGP. It is predicted that when the project is completed in 2009, the total investment will be controlled within RMB 180 billion (about USD 22 billion) without exceeding the budget, and in contrary, with some surplus.

- 三峡总公司通过改制成立了控股上市公司--中国长江电力股份有限公司，其“长江电力”股票已于2003年11月成功地在国内上市。三峡总公司正利用资本市场上的资金滚动开发新的电站项目。

China Three Gorges Project Corporation(CTGPC) has established via restructuring, China Yangtze Power Co., Ltd., a listed holding company. The “Yangtze Power” stock was successfully listed in Nov. 2003 in China. CTGPC are utilizing the funds raised on the capital market for rolling development of new hydropower projects.

- 三峡工程项目的开发历程可以看作是中国水电开发的一个典范，建立了一套有利于水电加快开发的机制。

The whole course of TGP development can be regarded as an example of hydropower development in China by establishing a set of mechanism favorable to accelerating hydropower development.

## 6. 可持续发展的电力政策建议

### Suggestions on Power Policy for Sustainable Development

**6.1** 水力发电是可再生的清洁能源，可以起到改善生态、保护环境的有效作用。环境形势要求：只要资源允许，应该尽量地开发利用水能，尽可能多地替代不可再生和污染环境的矿物燃料发电。

Hydropower is a renewable and clean energy source that can play an effective role in improving ecologic conditions and protecting environment. The status of environment requires that as long as hydropower resources are available, we should make the utmost use of this kind of energy and replace as much as possible the non-renewable fossil fuel generation that aggravates environmental pollution.



**6.2** 科学地评估每一个水电站的利弊得失。

Scientific assessment should be made about the advantages and disadvantages of each hydropower station.

**6.3** 良好的市场机制是发展水电的有利因素，应该加快电力体制的改革。

A sound market mechanism is a favorable factor for hydropower development, so we should speed up the reform of power system.

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**6.4** 小水电是可再生和清洁的能源，应该在政府政策上予以扶植，但也切忌盲目开发。

Small hydropower stations produce renewable and clean energy, which should be supported by government policies. The random development of small hydropower projects, however, must be avoided.

**6.5** 对水电开发实行优惠的税赋政策。对具有防洪功能的水电站，其发电税率要不同对待，因防洪属于非经营性的公众效益，应实行低税率。

Favorable taxation policy should be carried out in the development of hydropower. The tax rate for those stations with flood prevention function should be treated differently from others. As they provide non-profiting public benefits, these stations should be levied at lower tax rate.

**6.6** 在可见的未来30年内，中国的电力结构应将水力发电的比率从目前的24%提高到26%以上才是合理的，这是可持续发展的重要对策。

Within the future 30 years, it is reasonable to increase the proportion of the hydropower in the electric power structure of China from current 24% to more than 26%, which is an important countermeasure favorable to sustainable development.

**6.7** 为了适应经济的高速增长，中国的电力政策应立足煤电，但要逐步缩小其占有比率；大力发展水电，充分利用水能资源；加快核电建设的步伐，并积极进行风能、太阳能、生物能等新能源的商品化开发。

To accommodate the high-speed growth in economy, China's power policy should still focus on coal-fired generation, but gradually reduce its proportion in the whole power output. We should exert great efforts to develop hydropower and make full use of water energy resources; Simultaneously, we should accelerate nuclear power construction and actively make commercialized development of new energy sources like wind, solar and biomass energies.

A scenic landscape photograph of a mountain valley. In the foreground, there are dark, rocky slopes with patches of vibrant red autumn leaves. A river flows through the center of the valley, winding between steep, forested mountains. The sky is a clear, bright blue with a few wispy white clouds. The overall scene is peaceful and majestic.

**Thank you !**

**谢 谢 !**

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