Evaluation on the effect of dam engineering to atmospheric ecosystem

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[Abstract] Since 1961, with the increasing global population and consumption of fossil fuel as coal and petroleum, global temperature has been rising continually at an average speed of 0.2℃ per decade. As an engineering measure to harness hydropower, dams are playing more and more important role in slowing down the global warming process. In this paper, by comparing the Dagangshan hydropower station in China with a thermal power station of the same installed capacity, both positive and negative effect of dams to the atmosphere ecosystem are analyzed thoroughly. For the positive effects, (1) hydropower station can reduce the release of CO_2 by 648g/kWh compared with thermal power station; (2) Reservoirs formed by dams can improve the meteorological conditions in the reservoir area, enhancing the capacity of plants above the water level to absorb CO_2. For the negative effects, (1) the scale of dams is usually large and its construction will consume large amount of electricity, petroleum and construction material, indirectly emitting some CO_2; (2) the reservoir created by dam will inundate plants whose rotting will also release some CO_2.

Comparing the above indices of CO_2 release, the positive effects of power-generating dam engineering is far more superior to their negative effects to the atmospheric ecosystem.

[Key words] dam, CO_2 release, reservoir, atmospheric temperature

1、INTRODUCTION

Atmosphere is a necessity for the survival of mankind. However, with the large amount of consumption of coal, petroleum and other fossil fuels, the ecological environment of the atmosphere is experiencing unprecedented destruction. According to statistics, China consumed 1.32 billion tons of coal and 224 million tons of petroleum in year 2000, and the figures reached 2.167 billion tons and 325 million tons respectively in year 2005 with the average annual growth of 10.15 percent. Due to the significant increase of CO2, SO2, NO2, etc in the atmosphere, abnormal weather appeared in many places of China, such as the heat island effect in metropolitans during summer time, acid rain in the South. Therefore, from year 2000, the China Government began to implement a new energy development strategy: to develop hydropower and wind power vigorously, nuclear power actively and natural gas-generated power rationally, and to optimize the

proportion of coal-generated power constantly. At the same time, energy-saving and waste-reducing work is listed as an important target of national economic development by China government, and by 2010, the energy-consuming index is planed to reduce from 1.22 ton of standard coal in year 2005 to 1.0 ton for every 10,000 yuan of GDP. In July's G-8 summit held in Japan, China Government support the decision to reduce the release of greenhouse gases by 50 percent of the present level by 2050.

During the past 10 years, dam construction, as a necessity for hydropower development, has been questioned. One argument is that hydropower plants transmit clean electricity, so the dam itself is an environment-friendly facility, while the opposite view that dam construction occupies a large number of farmland and woodlands and consumes a large amount of building material, its reservoir filling inundates a large number of woodland and farmland and destroys the local ecosystem.

Obviously, for the dams to be constructed in China, it's necessary to use scientific attitude to evaluate theirs advantages and disadvantages to the atmospheric ecosystem thoroughly, thus to reach a consensus and to create a good external environment for construction.

2. Advantages and disadvantages of dam construction to the atmospheric ecosystem

2.1 The ecological benefits of dammed water resources to atmosphere

The dams have three main functions: (1) Flood control and disaster reduction. (2) Breed aquatics and tourism. (3) Hydropower generation. The first two have not direct relationship to atmospheric ecosystem. Upon the completion of a dam, a hydropower station with a capacity of a kwh can reduce the release of CO_2 by 0.648a kg and SO_2 by 0.0044a kg annually. The figure is based on unit coal consumption of 0.35 kg / kwh and CO2 release of 0.648 kg / kwh in thermal power plants provided by China government.

2.2 Dam construction consumes a large amount of building materials and energy and releases CO2 indirectly

Construction of dam and its affiliated power plant involve excavation and filling of earth and stone, production of sand and aggregate, concrete casting, electrical and mechanical equipment installation and so on. With the continuous progress of dam construction technology, a dam construction can be finished within 10 years from planning to completion. If the construction consumes energy of bi for the i year ($i<10$) and the transportation of cement and steel and other bulk goods consumes energy of ci, then the total energy consumption during construction of the dam is Σ (bi + ci). This part of energy consumption is equivalent to 0.648 Σ (bi + ci) (kg). of CO_2 release to

the air, based on the release index of thermal power plants.

2.3 The plants in the reservoir area cannot absorb CO2 after filling

For the fast-growing forests in mild region, their absorption capacity of CO_2 is 270 t/km2 annually. When they are destroyed, the decay of plant residues accumulatively releases CO2 of 500 t/km2. If the total area for the construction of a dam and its reservoir is S square kilometers, then the ability of CO2 absorption will reduce by 270 S (t), and the decay of underwater plant residues will add another 500 S (t) accumulatively.

2.4 Comprehensive analysis of dam construction to the atmospheric ecosystem

From above analysis, dam construction has both advantages and disadvantages to atmospheric ecosystem. If the life of the dam is n years, and the total amount of CO2 released from both dam construction and the plant decay under its reservoir is averaged by n year, then index of dam to the reduction of CO2 release would be $F = [0.648 \Sigma (bi + ci) + 5 \times 10^5 S] / n + 27 \times 10^4 S - 0.648a$, where the unit of F is kg, $i \leqslant 10$, $n \leqslant 200$. If $F < 0$, then index of dam to the reduction of CO2 release is good.

3. Case history

3.1 Impacts of Dagangshan hydropower station, Dadu River to atmosphere

Dagangshan Hydropower Station is composed of a 210 m-high concrete arch dam and an underground powerhouse with an installed capacity of 2600 MW. Upon completion, the power station bears a multi-year average power-generating capacity of 11.4 billion kwh. Major indices of the project include excavation of earth and stone 12.77 million m3, concrete casting of 4.57 million m3, mechanical and electrical equipment installation of 24,000 ton. It takes about nine years from 2006 to 2014 to finish the dam. The multi-year average temperature is 15.40 C and the rainfall is 642 mm in the dam area, and the total area of the reservoir-inundated woodland is 13.56 km2.The impacts of the dam to atmospheric ecosystem are analyzed as follow.

fig1 Dagangshan dam

(1) The annual 11.4 billion kwh of hydropower saves 3.99 million tons of standard coal, reducing 7.39 million tons of CO2 release each year based on release index of thermal power plants.

(2) Within the nine years of construction, the yearly average power of all kinds of construction equipment is 3000, 4000, 4500, 4500, 6000, 7000, 7000, 8000, 9000 and 6000 kW respectively. Supposing the average usage of the

construction equipment is 6000 hours, the total consumption of electricity during the construction is 354 million kwh, which is equivalent to CO2 release of 228,700 tons in thermal power plants.

(3) Within the nine years of construction, the yearly average power for transport equipmenta is 2000, 2500, 3000, 3500, 4000, 5000, 5000, 5500 and 5000 kw respectively, the energy used for transportation of bulk materials is 175 million kwh, which is equivalent to release 113,400 tons of CO2 in thermal power plants.

(4) After the 13.56 km2 of woodland is inundated or decomposed in the damsite and in the reservoir area, the total CO2 release will be 6780 tons.

(5) After the 13.56 km2 of woodland is inundated or decomposed in the damsite and in the reservoir area, 3661 tons of CO2 absorption by local environment will be reduced.

fig2 the Dagangshan reservoir area

If Dagangshan arch dam can stands for 200 years (a conservative figure), then index of dam to the reduction of CO2 release is 0.174 +0.3661-739 = -7.3846 million tons. That is, when various factors are considered, the dam can reduce the release of CO2 by 7.3846 million tons to the atmosphere annually, compared with an equivalent thermal power plant.

If compared with a thermal power plant of capacity of 11.4 billion kwh, its total amount of engineering is equivalent to concrete casting of 300,000 m3, its plant electricity usage is 7%, construction period is three years and the plant can be used for30 years, then the equivalent CO2 release will amount to 203,000 tons for its material transport and construction, and to 7.9 million tons annually during operation period, 29.7 times as that by the construction and reservoir filling of Dagangshan Hydropower Station.

3.2 The environmental benefits of Ertan Dam, Yalong River

The China Ertan concrete arch dam is 242 m high with an installed capacity of 3300 MW and a multi-year average generating capacity of 17 billion kwh. Its reservoir extends for 145 km long with an area of 102 km2. The dam construction commenced in 1989 and ended in 1998. After the completion of the dam, climate in the reservoir area changes drastically. Its winter temperature increases by around 2^{0}C, while its summer temperature drops almost 2^{0}C than before. Before dam construction, the multi-year average rainfall in the dam site area is 700 mm and it seldom rains during the dry season. After dam construction, the average rainfall in the reservoir

area increases by 50 mm and it often has flurry in the dry season. According to statistics, 90 percent of electricity consumption of Panzhihua City, 46 km away from the Ertan Dam, is from the clean energy supplied by Ertan power station, which greatly improves the city's the atmospheric environment with the reduction of coal consumption. In May 2006, the Ertan dam won the national environment-friendly project prize awarded by China Government.

fig3 the ertan dam

4. Conclusion

(1)The dams with power generation function can do more advantage than harm to the atmosphere ecosystem.Dagangshan hydropower station in China can reduce the CO_2 emission by 7384.6 million tons each year.On the other hand, the rotting plants below the reservoir water level can release some CO_2 during the building time and operating time,and it will release 1.74 million tons every year. Though the reservoir would inundate woodland, reducing the absorption of CO2 by 3.66 thousand tons each year, the negative effect is far less than the positive effect.

(2)Reservoirs formed by the dams can improve the local climate conditions.After the adjustment of the reservoir,the temperature and the water vapour content will be more suitable for the survival of animals and plants .

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