World Water Congress XV
International Water Resources Association (IWRA)
Edinburgh, Scotland 25 - 29 May 2015

Water-Energy Nexus in China: New Challenge for Water Management

Prof. Yangwen JIA

China Institute of Water Resources and Hydropower Research

Mon (May. 25) 14:46-14:57

Outline

1. Background
2. Key technologies for present water and energy issues
3. Co-benefits of coal consumption cap policy on water resources
4. Summary

1 Background

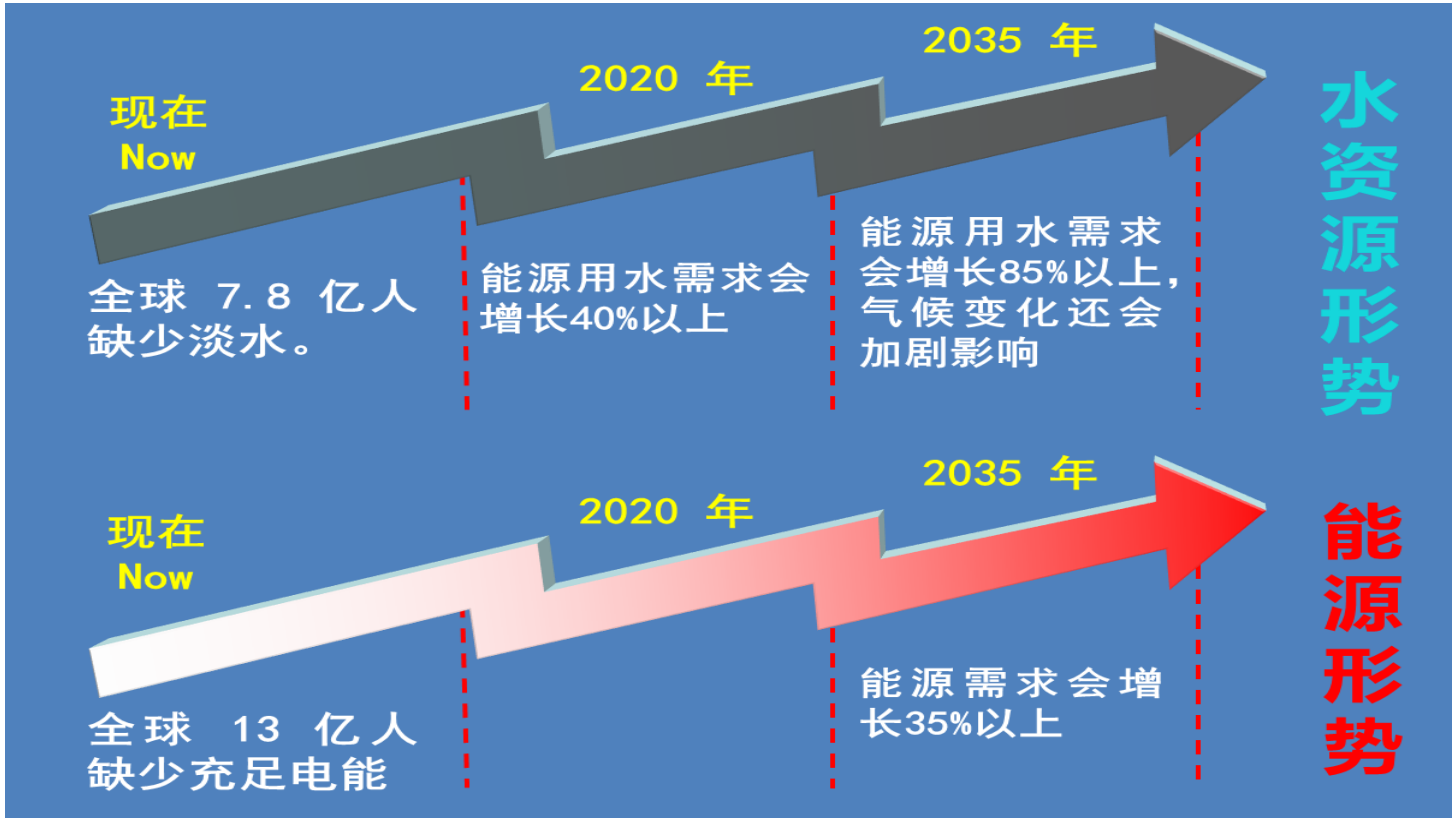
Global continuous population growth and rapid socio-economic development have caused water stress and energy crisis , which further brought a series of eco-environmental issues because of improper development of water and energy.

1 Background

Water and Energy is the most vital factors to global sustainable development.

Water situation

Energy situation

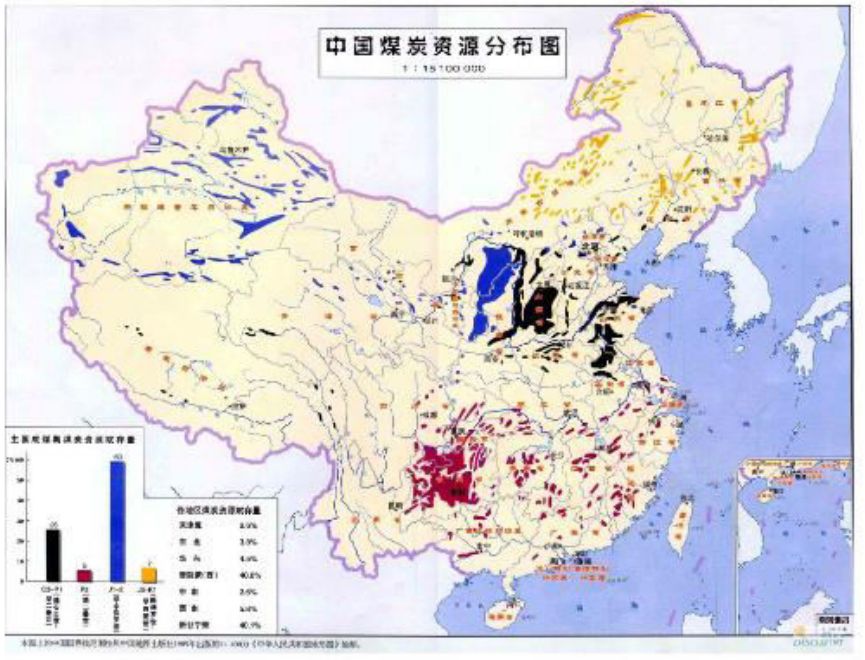


780 million people under drinking water crisis and 1.3 billion people suffering energy and power shortage.

1 Background

As in China, most of energy bases, especially for coal, are located in arid and semi-arid northern regions, showing reverse distribution between energy and water resources.

Distribution of rainfall in China



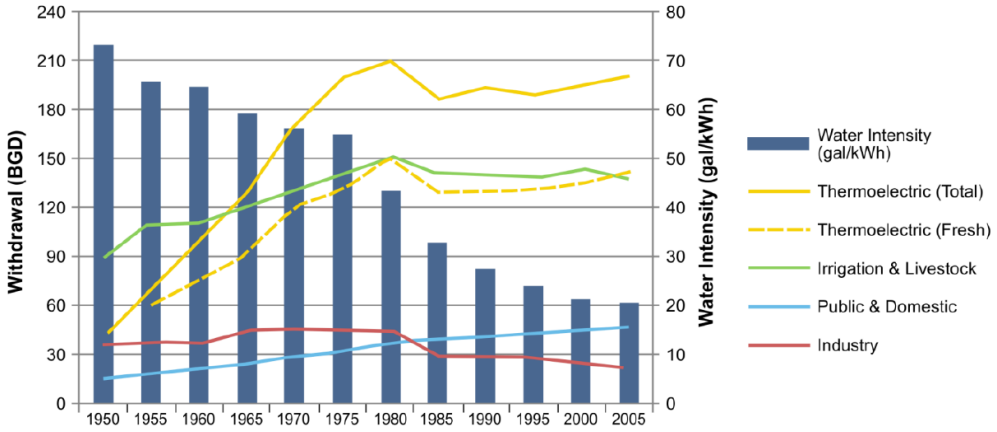
Distribution of coal reserve in China

1 Background

Increasing water use of energy sector, competing with other industries

Nowadays, vigorous development of energy promotes prosperity of related industries, but also aggravates water stress in water deficient area by competitive water use with other industries, so that **contradiction between reduction of water resources and rising demand for energy becomes bottleneck factor for future development**.

Water use for thermoelectric generation and other sectors*

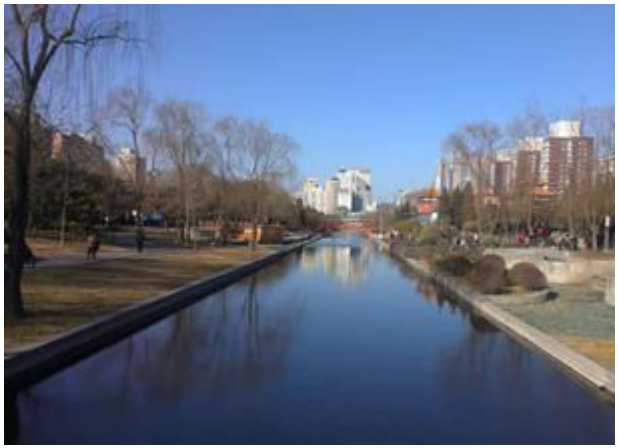


*. Water Energy Nexus Executive Summary July 2014 by U.S. Department of Energy

1 Background

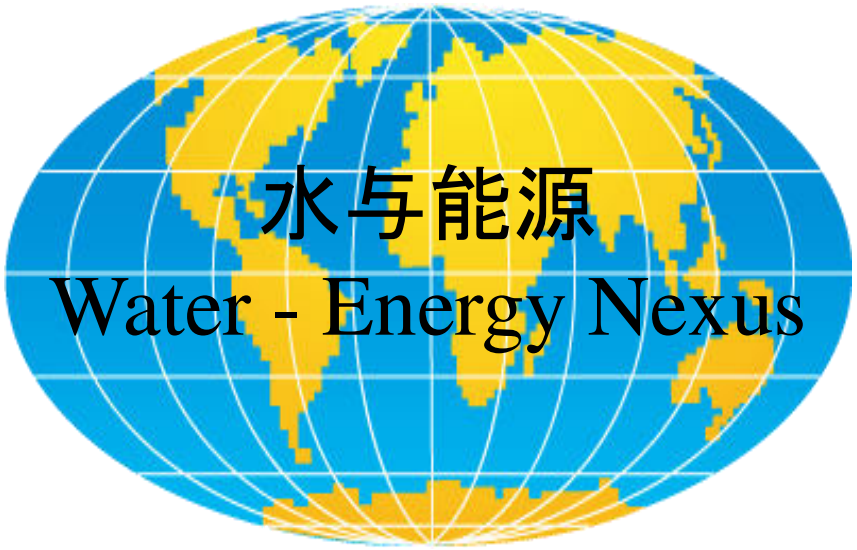
Competing with ecology and environment

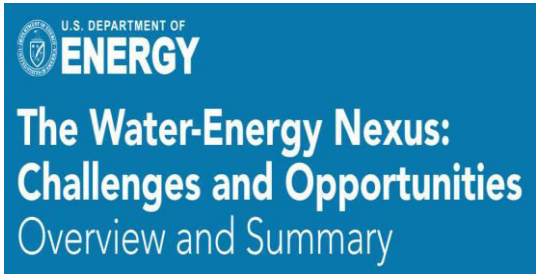
The conflict of volumes of water demand in energy bases and local eco-environment protection challenges the strategy of ecological civilization currently carried out in China in view of fundamental resource base role of water resources in ecological civilization construction.



Ecological Civilization Construction

As a consequence, researches on water-energy nexus and synergetic exploitation and management of water and energy are in urgent need to ensure sustainable prospects on water and energy use by human beings.



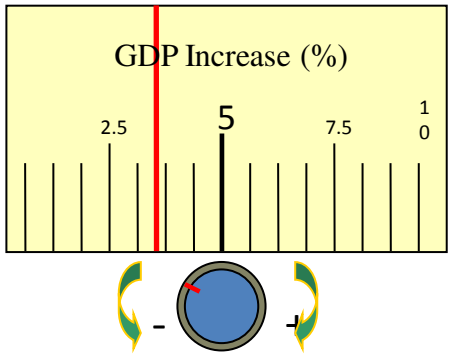


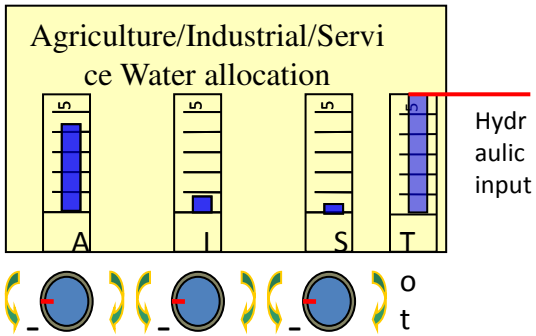
- In the report by IEA ***World Energy Outlook 2012*** come to the conclusion: Energy will face the thirsty
- The World Bank carry out the “Thirsty Energy Action Plan” all over the global.

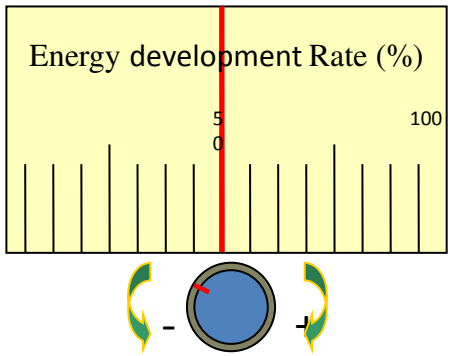
2. Key technologies for present water and energy issues

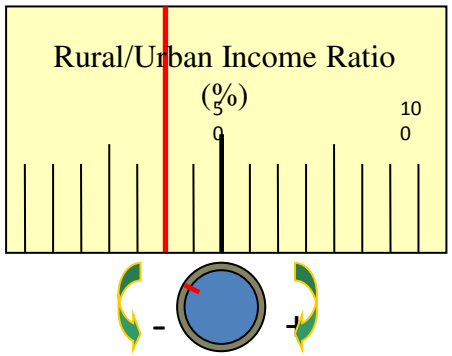
1) Water-energy nexus and synergetic effects study

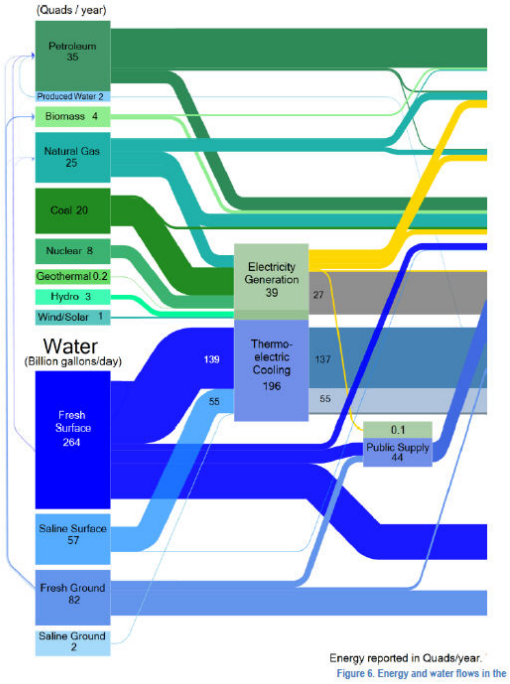
The quantitative relationship between water resources and energy consumption and realization of sustainable development are to be studied, as well as diagrams of water flow and energy flow, and synergetic policy, planning and management.







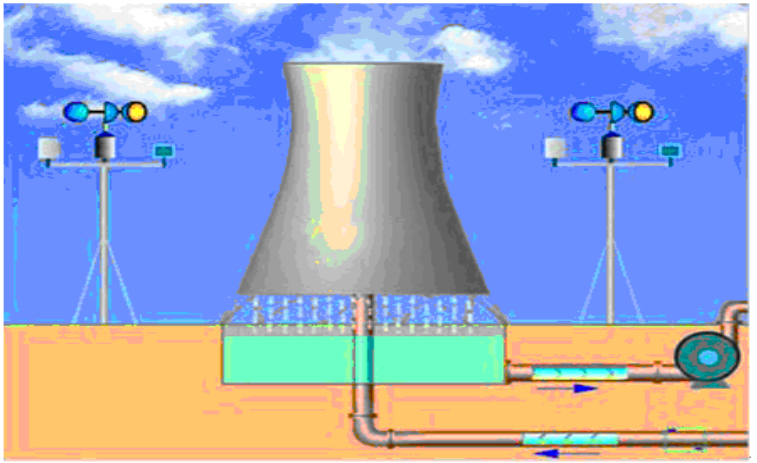




2. Key technologies for present water and energy issues

2) Key technologies at microcosmic layer

- ✓ water-saving technologies in energy exploitation
- ✓ waterless fracturing
- ✓ dry-cooling or water-saving cooling technologies
- ✓ efficient desalination of salt water
- ✓ real-time sensor system for water quality and quantity measurement in energy operation



2. Key technologies for present water and energy issues

3) Ecological regulation for hydropower projects

Massive hydropower projects and socio-economic water use lead to ecological base flow deficit in dry season, thus researches on minimum environmental flow, ecological operation technology of hydraulic engineering, joint regulation of water quality and quantity, are necessary.

2. Key technologies for present water and energy issues

3) Ecological regulation for hydropower projects

It's worth noting that, in the '*Water pollution control action plan*', known as 'Ten Rules for Water', recently released by the State Council of China.

"Scientifically determine ecological flow. Carry out pilot works in the Yellow River basin and Huai River basin; determine ecological flow and water level by stages and take them as essential reference for basin water operation."

Target values of eco-environmental flows at key sections

Unit：m^3/s

Section number	Section name	Extremely low eco-flow	Low limit eco-flow	Appropriate eco-flow
2#	Lin Jiacun	5.4	8.6	12.8
7#	Wei Jiabao	8.4	11.6	23.5
12#	Xianyang	10.0	15.1	31.7
18#	Lintong	12.0	20.1	34.3
22#	Huaxian	12.0	12	34.1

The eco-environmental flow indices have been adopted by local water administration authority as ecological regulation goals in mainstream of the Weihe River.

Linjiacun Station, April, 2014

2014.03.12 星期三 华商报 新闻热线：029-88880000

图编/李琦 校审/赵艳华

保障下游生态来水，当年11月至次年6月——

渭河干流3电站非汛期关停8个月

本报讯（记者 郝蕾 通讯员 汤少林）渭河干流生态来水持续减少，非汛期渭河“首尾有水中间干”现象日益严重，为此，我省日前决定，在非汛期暂时关闭渭河干流上的三座水电站，确保下游生态来水。

据省水利厅统计，近十年来，我省渭河全流域水资源总量减少16%，耗水却增长了53%，渭河来水年内、年际间相差7至10倍，加之干流上没有大的调蓄工程，河道在非汛期往往出现严重的“首尾有水中间干”现象。特别是渭河宝鸡市至咸阳市武功段，有的水文断面监测到的流量仅有不足5立方米/秒，对下游的生态用水造成威胁。

近日我省决定加强渭河水量调度，对宝鸡峡渠首枢纽以下实行非汛期（当年11月至次年6月）水电站全部关闭，汛期合理引水发电，保证渭河干流生态流量。这涉及到渭河干流上的魏家堡、杨凌、绛帐等三座电站，由于没有专门的水库，这三家水电站是在渭河干流上拦坝蓄水发电，在渭河枯水期时，水电站直接拦截了渭河来水，导致下游来水不足。

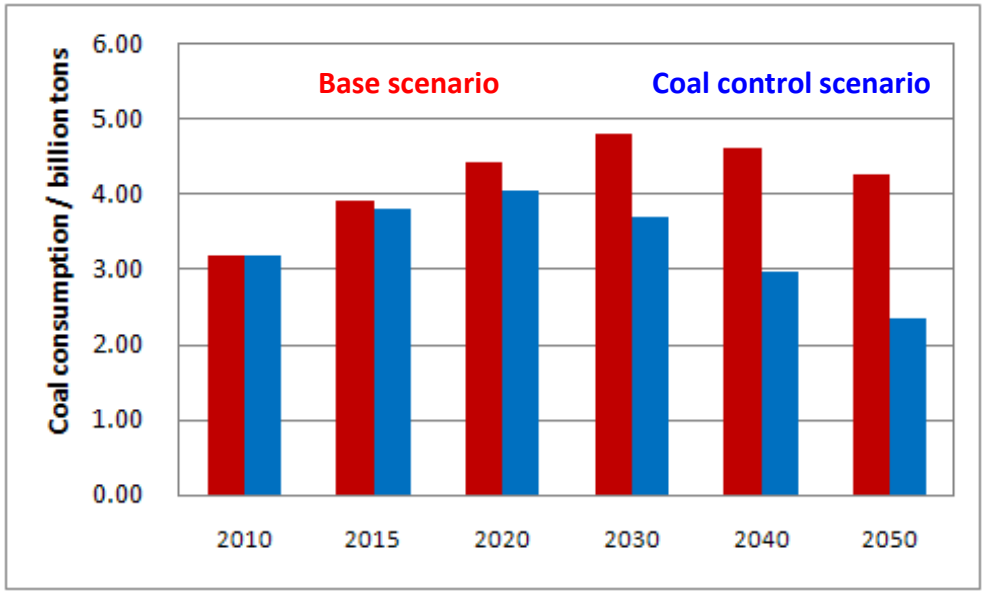
今年起，这三座水库须在每年11月至次年6月的8个月里，全部关闭不再拦水发电，确保将渭河干流宝鸡至武功近100公里河道的生态流量，提高到8.6至20立方米/秒的合理区间，虽然会牺牲局部利益，却能获取渭河水生态效益的最大化。

这三家水电站在每年汛期（7月至10月）可通过调蓄，在保证下游河道来水量的基础上，合理引水发电。

3. Co-benefits of coal consumption cap policy on water resources

3.1 Coal consumption control schemes

- The base scenario and coal control scenario are brought forward by NRDC according to collection and coordination of each subtopic's result with consideration of both resources and environment constraints and development demand of coal related industries .
- Generally, the coal consumption of coal control scenario are lower than those of base scenario. The peak of coal consumption of base scenario is 4.8 billion tons in 2030, while that of coal control scenario is 4.0 billion tons in 2020, indicating obvious influence of coal control policy on coal consumption.



Year	Base scenario (billion tons)	Coal control scenario (billion tons)
2010	3.20	3.20
2015	3.92	3.80
2020	4.44	4.06
2030	4.82	3.70
2040	4.62	2.97
2050	4.26	2.35

3.2 Effects of coal consumption cap schemes on total water use

- The overall water use during coal consumption is consist of coal mining and washing water use and coal utilization water use.

- Water use of coal mining and washing relate closely with coal production and spatial distribution..

- Water use of coal utilization are mainly influenced by total amount of coal consumption and corresponding departmental structure.

3.2 Effects of coal consumption cap schemes on total water use

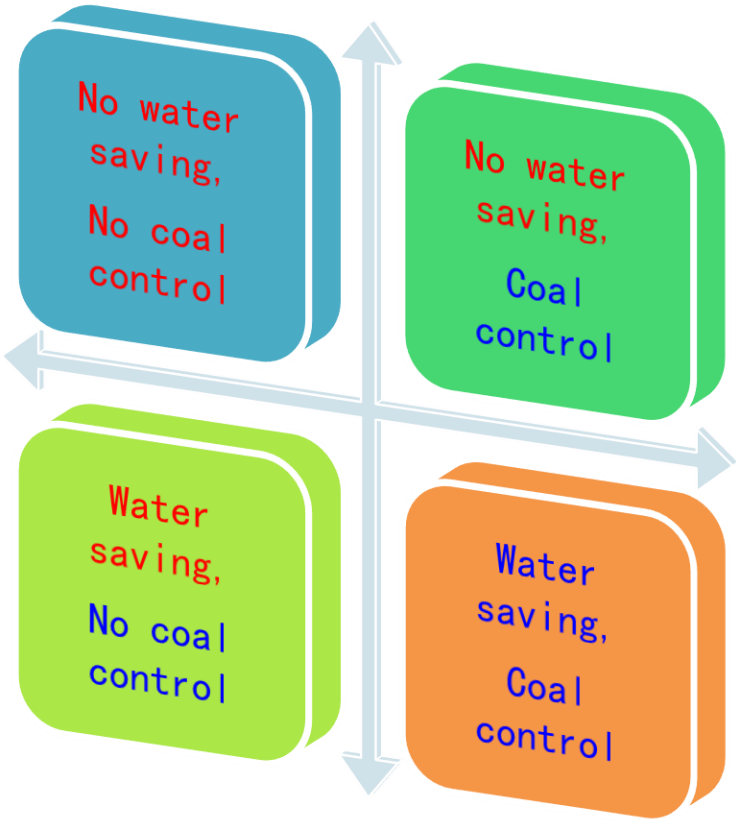
- The effects of coal consumption control on water resources

- On one hand, coal consumption control reduces coal production and utilization so that water use during coal mining and utilization as well as mining water flow will decrease immediately.

- One the other hand, coal consumption control indirectly promotes readjustment of energy structure and water consumption structure, therefore water use will decrease due to water-efficient alternative energy consumption and water-saving technology application.

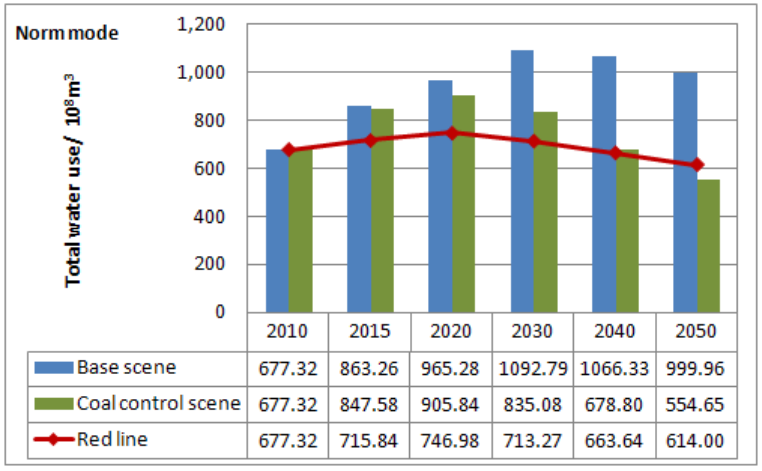
3.2 Effects of coal consumption cap schemes on total water use

- Two modes of water use are considered including normal mode and water-saving mode. In normal mode, total water use of each department are calculated on basis of current water use quota, while in water-saving mode, low water quota is adopted in newly increased capacity of coal related industries with backward technique gradually eliminated.
- Combing coal consumption control scenarios and water-saving modes, four schemes are considered.

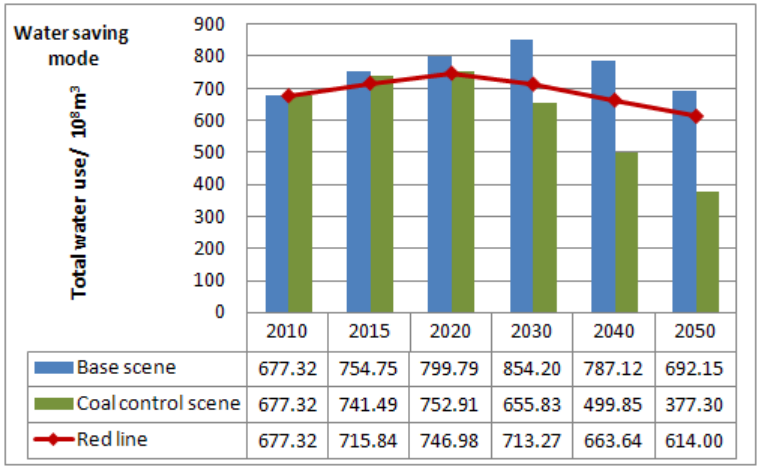


3.2 Effects of coal consumption cap schemes on total water use

- Comparing results under norm mode and water saving mode, the total water use of coal consumption under norm mode is much bigger than that of water saving mode, indicating that applications of water saving technology could greatly restrain total water use growth with increasing coal consumption .
- Comparing results under base scenario and coal control scenario, the total water use of coal consumption under coal control scenario is less than that of base scenario, and coal consumption control makes positive contribution to water use control.
- Both of coal consumption control and water saving technology are indispensable for coordination and sustainable development of coal industries and water resources under the most strict water resources management policy.



Water use of coal consumption under norm mode



Water use of coal consumption under water saving mode

3.3 Effects of coal consumption cap schemes on water conservation

- The impacts of coal mining and utilization on water quantity and quality of surface water and groundwater, as well as geological environment, are much lower under coal consumption control scenario than that under base scenario.
- The total water use of coal mining and utilization under coal consumption control scenario is much less that that of base scenario, which would be helpful for the regional water use control to meet the requirement of corresponding water use red line.
- The impacts of coal mining and utilization on regional water cycle and eco-environment are much lower under coal consumption control scenario than base scenario, which would play a positive role in water resources conservation and environment improvement.

4. Summary

- The current and future situation about water and energy nexus is discussed in this paper.
- Several key technologies are desired for present water and energy issues, i.e. water-energy nexus and synergetic effects study, key technologies at microcosmic layer & ecological regulation of hydropower projects etc.
- Coal mining and utilization impacts on water resources is studied. It's concluded that coal mining and use should satisfy the principle of coordination between coal production and carrying capacity of water resources and environment.


Thank you !