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Ideas for Building China's Future-oriented Conceptual Wastewater Treatment Plant

QU Jiuhui, WANG Kaijun, WANG Hongchen, YU Gang, YU Hangqing, KE Bing

Our consensus：

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Have to search for possible ways to optimize the use and recycle of all resources in the world.

Wastewater is a very important resource rather than a kind of waste.

Water reclamation should be a integrated process

- **Water reuse**
- **Energy recovery & Nutrients recycle**
- **Eco-risk free and environment-friendly**

Maximizing the Benefits of Water Reclamation

In early 2014, we proposed…

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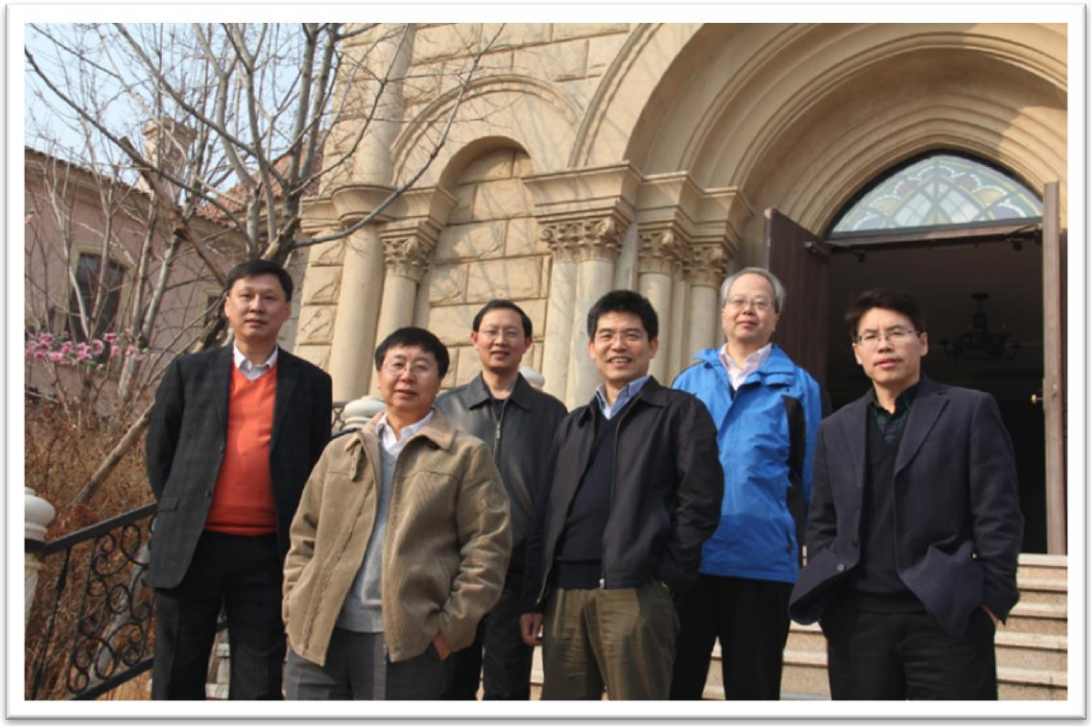
To Build China's Future-oriented Conceptual Wastewater Treatment Plant



WANG Kaijun,QU Jiuhui,YU Gang,KE Bing,
YU Hangqing,WANG Hongchen(From left to right)

10| 水 Water 产业周刊

建设面向未来的中国污水处理概念厂

污水处理功能变化明显

专家认为——

历史上的"概念厂"

基本建设完成不等于发展停滞

践行先进理念 满足战略要求

面向未来的一次系统探索

建设面向未来的中国污水处理概念厂

Our Objectives

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To build up a (series of) future-oriented (2030-2040) domestic wastewater treatment plant with a timeline of five years.

Water Factory 21, California

"NEWater", Singapore

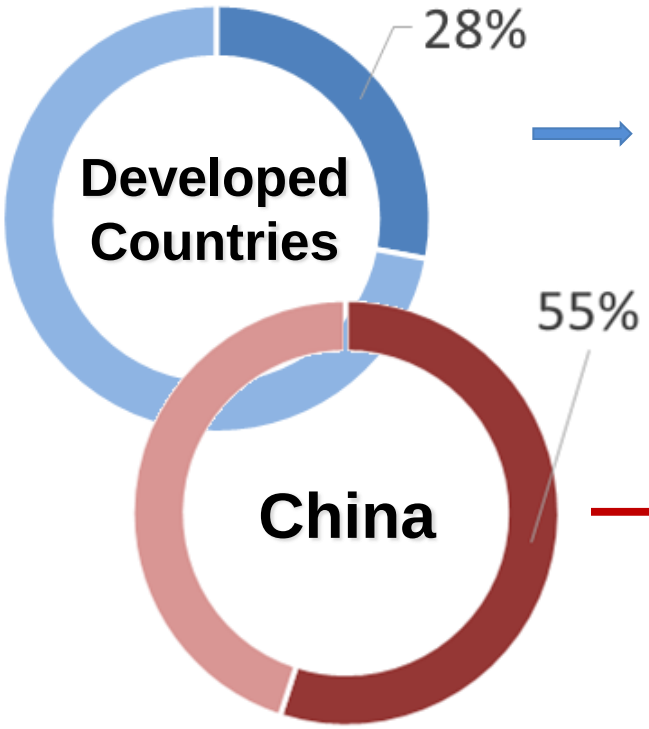
1. Background of our activity

(1) Emerging Urbanization

- **100 million inhabitants from rural to urban**
- **Reformation of “village-amid-the-city”**
- **Urbanization in the mid-western regions**

--“The 12th session of the National People's Congress at the 2nd meeting of the government work report”

1. Background of our activity



Comparison of Percentages of Rural Inhabitants in the cities

Urbanization in western countries come to the end

The biggest market of wastewater treatment in the world

1. Background of our activity

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(2) Energy recovery & Nutrients recycle

Energy-costly, resource-consuming, unsustainable development

Violation of the sustainable concept

- **Lack policy guidance**
- **Extensive Management**
- **Energy-costly Process**
- **No resource recovery**

1. Background of our activity

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The present and future of China's WWTPs

- There are about 4000 WWTPs in China
- Treatment capacity is 149 m m^3/d
- According to the I B effluent standard, the total annual mitigation of COD, N and P are 10m, 2m and 0.2m tons.
- 10 billion kWh of power is consumed in the processes in one year.
- Meanwhile, the conventional treatment processes may lead to energy waste of 20 billion kWh which could have been derived from the produced COD.

1. Background of our activity

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(3) Pollutant Reducing

The daily domestic sewage in China

- The Chinese population=1.4 billion
- 50% of people live in cities
- Average sewage generation of each person is : 0.14-0.24 m^3/d
- Accordingly, the Chinese annual generation of sewage is 46 billion tons.
- 15 m tons of COD, 3 m tons of N and
- 0.25 m tons of P contain in the wastewater.

1. Background of our activity

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Pollutant Reducing

- More complicated pollution and increasing sorts of pollutants
- Increasing requirements of water environment

More stringent effluent standard → Technical Development → Nutrient Removal → Biological (BNR) / Enhanced (ENR) / Limit of Technology(LOT)

Nutrient Removal → Advanced Treatment → Advanced Oxidation / RO

Eutrophication

1. Background of our activity

More Stringent Standards

- Standards for sewage (mg/l)

  1A:COD 50、N15、P 0.5(1.0)

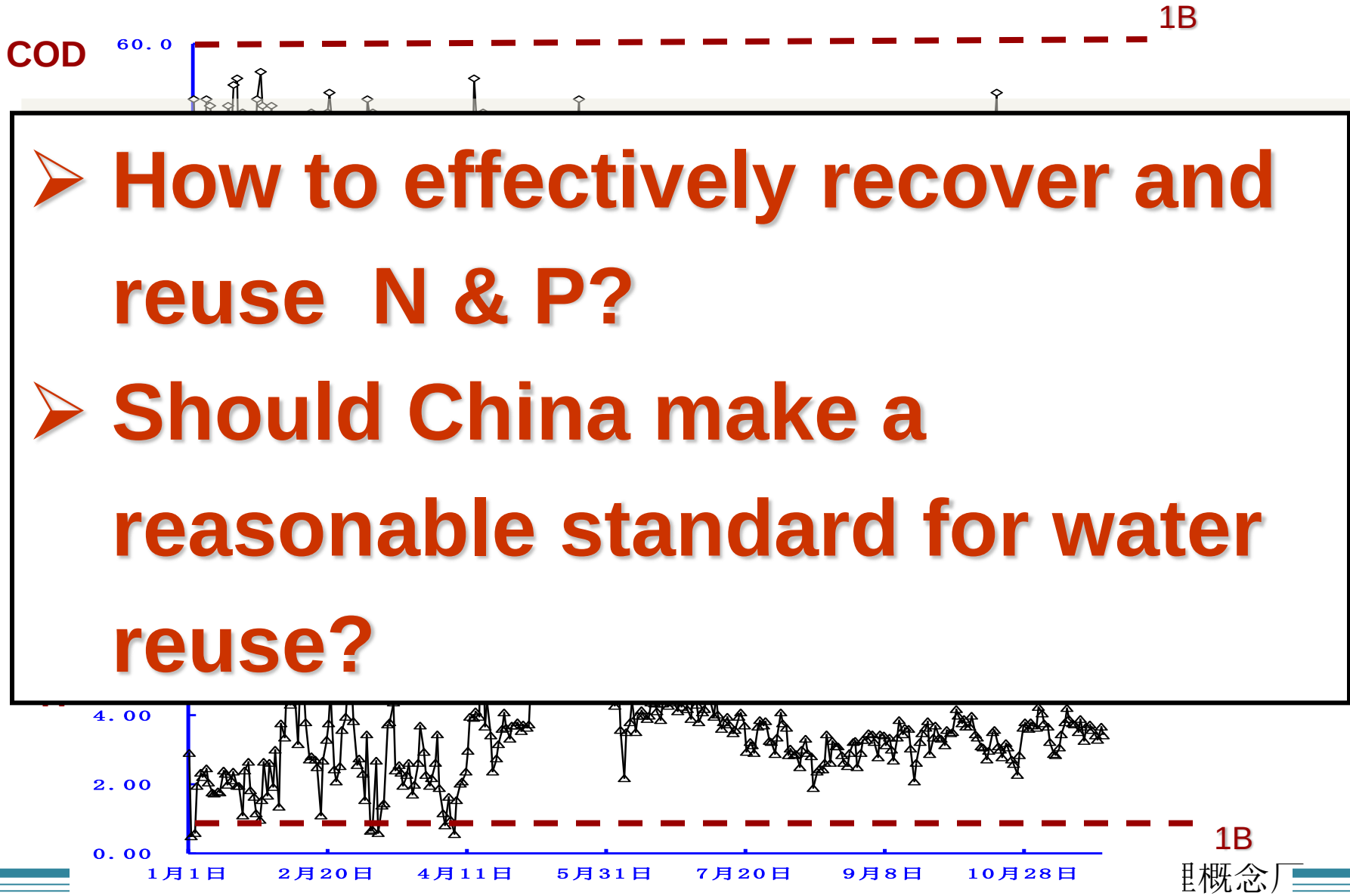
  1B: COD 60、N 20、P 1.0(1.5)

- Standards for industrial WW (mg/l)

  COD: from 100-150 to 60-100

Upgrading of facilities or introduction of advanced treatment is required.

1. Background of our activity



- How to effectively recover and reuse N & P?
- Should China make a reasonable standard for water reuse?

2. China's Conceptual WWTP

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Integration of Wastewater Treatment & Energy & Nutrient Recovery

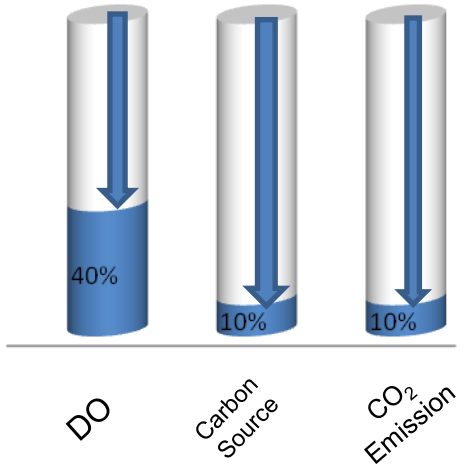
- Potential Energy in wastewater =10 x energy cost for treatment
- Electricity yearly cost for China WWTPs is over10 billion kWh
- Energy Potential in global daily wastewater discharge ≈ 100 Mton standard fuel oil
- Energy self-sufficiency rates of some WWTPs are already 100%
- Phosphate Recovery is an important development direction

Perception Change

Resource Recovery

Technology Innovation

- **Nitrogen Removal**
- **Co-digestion**



2. China's Conceptual WWTP

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Design Criteria

- Low-Carbon Footprint
- State-of-the-art Technologies
- Sustainable
- Global Benchmark

Seek the suitable model of wastewater treatment and reuse for China

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- Human Capitals
- Experience
- Technologies

→ **ready to launch**

A leap-frog progress

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Four Objectives

- **Sustainable Water Quality**
- **Energy Self-sufficient**
- **Resource Recovery**
- **Eco-friendly**

2. China's Conceptual WWTP

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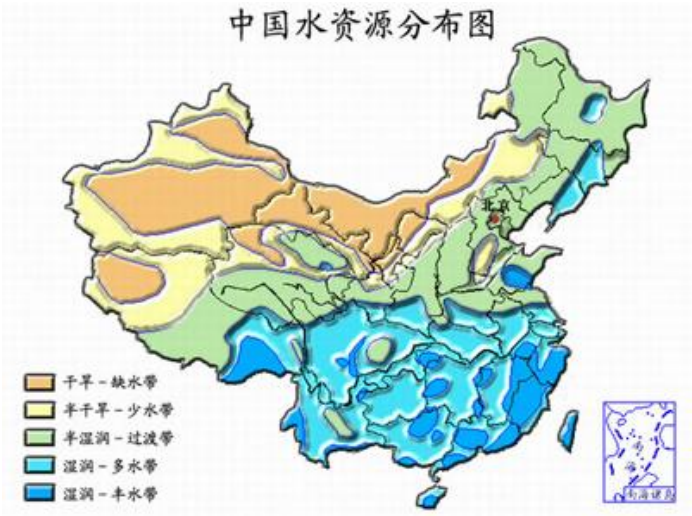
1 Sustainable Water Quality

Ignorance of ecological diversity, technical feasibility and economic availability



序号	基本控制项目		中国 二级标准	一级标准 B 标准	一级标准 A 标准	北京地方标准 B 标准	北京地方标准 A 标准		美国 国家标准	佛罗里达州 Hookers	Largo	Reno-Sparks	River Oaks	Palmetto
1	化学需氧量（COD）		100	60	50	30	20	BOD	30	5	5	20	2	5
2	生化需氧量（BOD_5）		30	20	10	6	4	SS	30	5	5	20	2	5
3	悬浮物（SS）		30	20	10	5	5	总氮		3	8	5	1.2	3
4	动植物油		5	3	1	0.5	0.1	总磷		7.5	--	0.4	0.4	1
5	石油类		5	3	1	0.5	0.05							
6	阴离子表面活性剂		2	1	0.5	0.3	0.2							
7	总氮（以 N 计）		-	20	15	15	10							
8	氨氮（以 N 计）		25(30)	8(15)	5(8)	1.5(2.5)	1.0(1.5)							
9	总磷（以 P 计）	2005 年 12 月 31 日前建设的	3	1.5	1	0.3	0.2							
		2006 年 1 月 1 日起建设的	3	1	0.5	0.3	0.2							
10	色度（稀释倍数）		40	30	30	15	10	pH	6-9					
11	pH		6-9	6-9	6-9	6-9	6-9							
12	粪大肠菌群数（个/L）		10^4	10^4	10^3	10^3	500							

单位：mg/L

中美两国排放标准对比图

Lack of sustainable discharge standard

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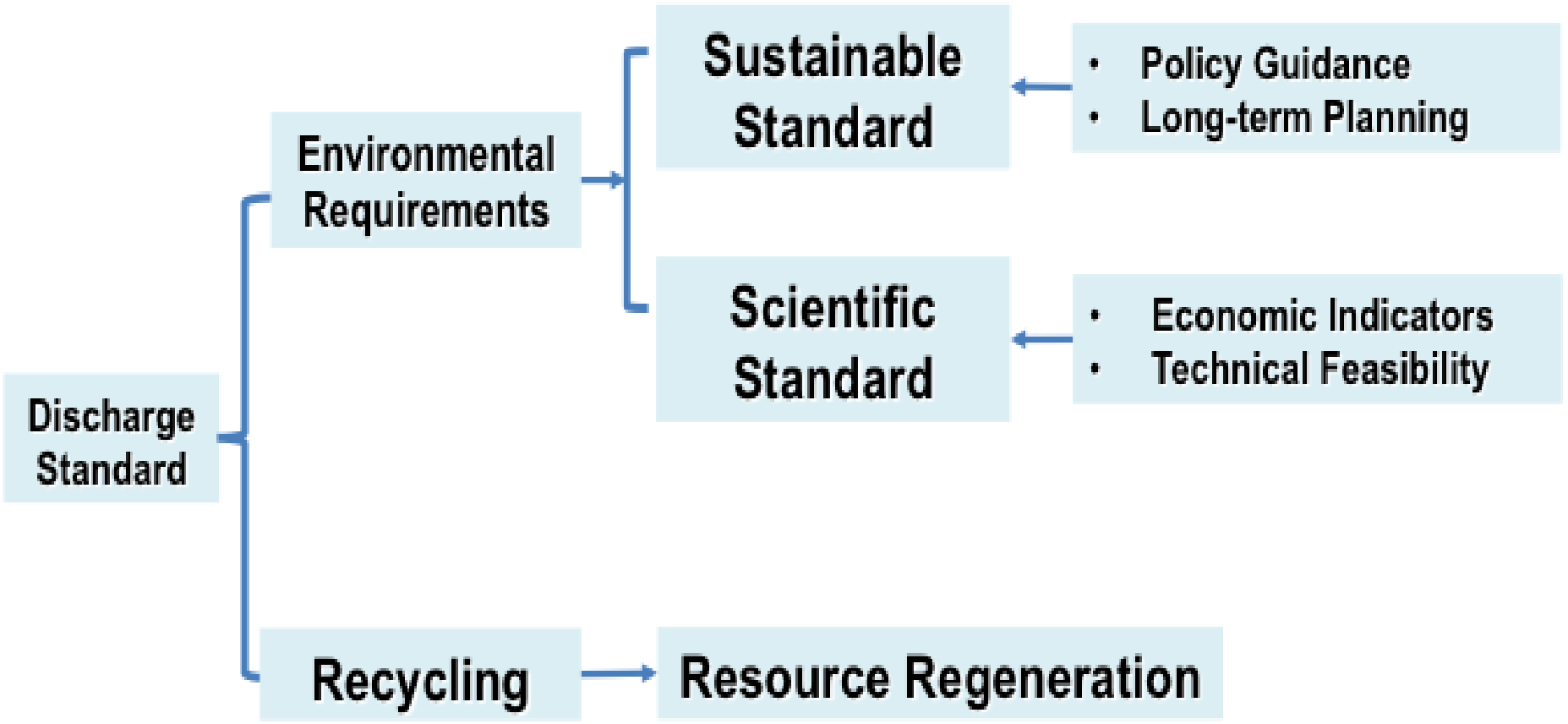
Sustainable water quality should meet the following conditions：

- **Achieve emissions requirements**
- **Conform to the goal of different recycling water quality requirements**
- **Ecological risk Free**
- **Meet the requirements for quality of the raw water as a drinking water, and have no health hazard**

Building the quality index system of sewage water which can be used to the next 20 years

2. China's Conceptual WWTP



2 Energy Self-sufficient

The energy contains in daily sewage in China

The 15 m tons of COD in the sewage may:

- **Be used to generate 30 billion kWh of power**
- **Be 3 times of WWTPs' energy consumption**
- **Achieve energy saving of 25%, if 10% of the total energy can be utilized**

4. China's Conceptual WWTP

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Reasonably use organics abundant power, new processes, techniques, rigs and ways of operation

Kitchen waste

Solar power

Information platform

Could reduce 1% of the society's energy consumption in the direction of the conceptual plant

2. China's Conceptual WWTP

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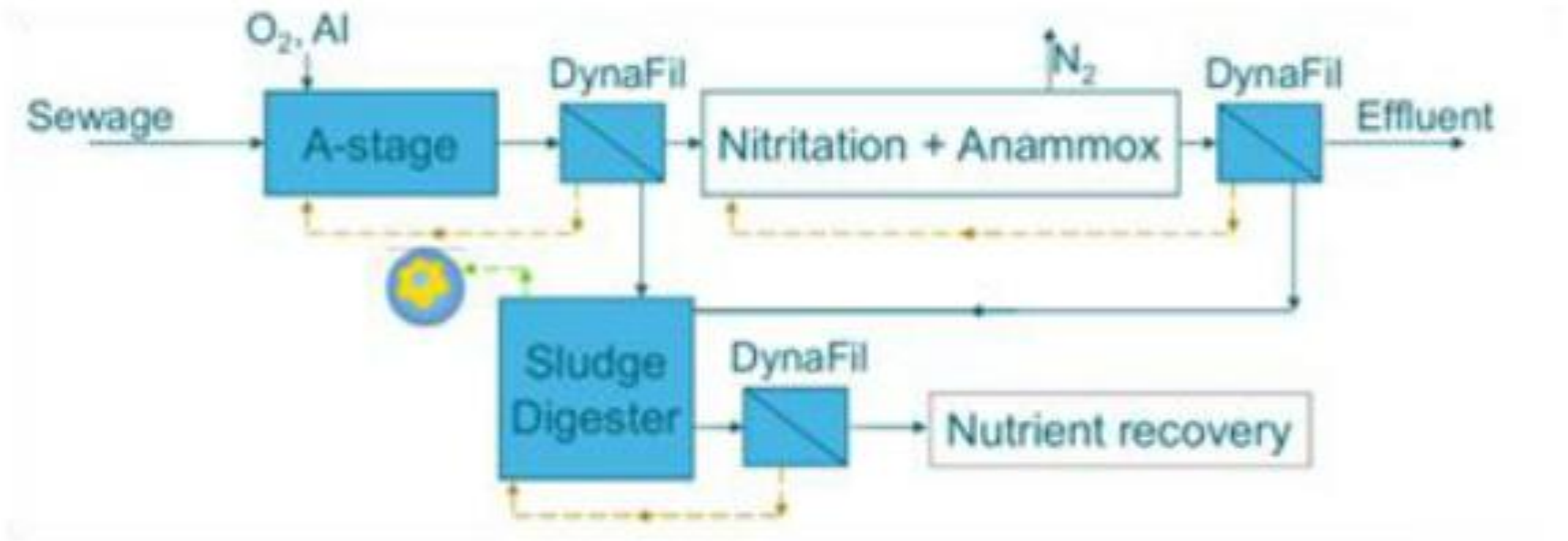
The Strass municipal wastewater treatment plant in Austria — energy consumption of Sewage treatment

A 83% drop of energy consumption. 2005's energy-sustain rate is as high as 108%, and can reach 200% when extra feedstock presents.



4. China's Conceptual WWTP

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3 Resource Recovery

Sludge Resource Utilization

a) Struvite,
b) Polyhydroxyalkanonate bioplastic,
c) Alginate biopolymers

4. China's Conceptual WWTP

China's annual discharge of COD, N and P are 23.5m, 4.5m and 0.49m tons, 65%, 66% and 53% of them come from WWTPs.

Hence, the utilization of energy and resources contain in wastewater may contribute to matter recycle and environmental protection.

4. China's Conceptual WWTP

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Phosphorus Recovery – Need

✦Globally, only about 16% of mined P ends up in human food. Most of the rest is lost along the way to agricultural run off (46%) and animal wastes (40%).

✦Major P reserves are present in only five countries, and "cheap" reserves will deplete in a few decades.

✦ We must recover the "lost P" in order to sustain modern agriculture, as well as protect water quality

✦from eutrophication.

Prof. Bruce E. Rittmann, Arizona State University

Recycling mode of N P

Technical route selection of Phosphorus resource utilization

Reclaim + Reuse vs.
Reuse directly

1.Deprivation and separation of P: obtain P products via Guanite crystallization technics.

2.Direct reuse: with in the water treatment process, P is concentrated in bi-products such us biogas slurry, and could be applied to agriculture use.

Agriculture use of P biogas slurry——economical feasible way for N&P utilization in the future

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4 Eco-friendly

- Safe Discharge
- Harmonious Integration with residency
- No affect to the surrounding landuse

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Lack of the harmony between human and nature

Sludge Disposal

17% → Unknown

80% → Landfill

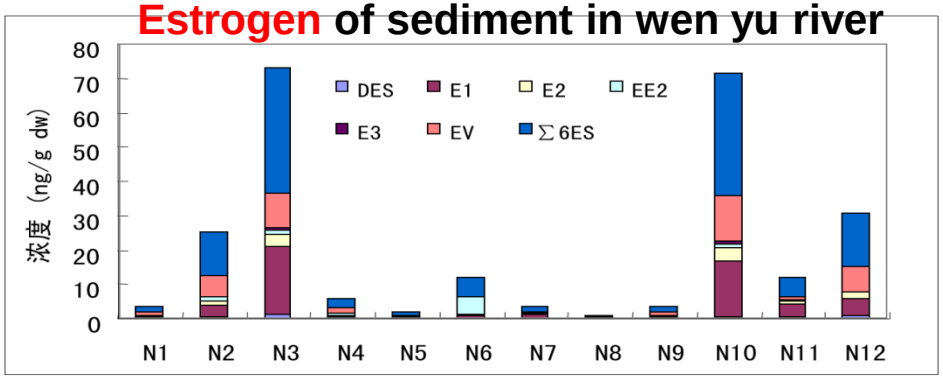
Resource Potential!

Nuisances with surroundings

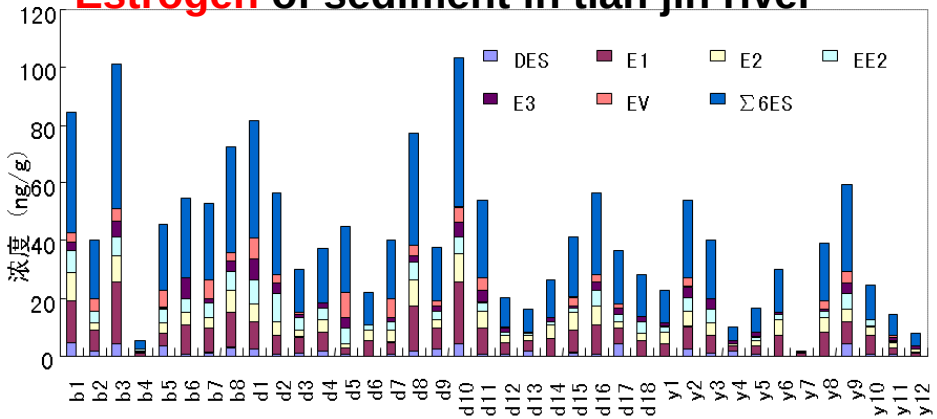
Sewage discharge-estrogen pollution

- **Estrogen**： **Diethylstilbestrol, estrone, estradiol, alkynyl estradiol, estriol, pentanoic acid estradiol**
- **Sample analysis: water and sediment in wen yu river, dagu sewage river, beitang drainage river and yongding river**

Estrogen of sediment in wen yu river

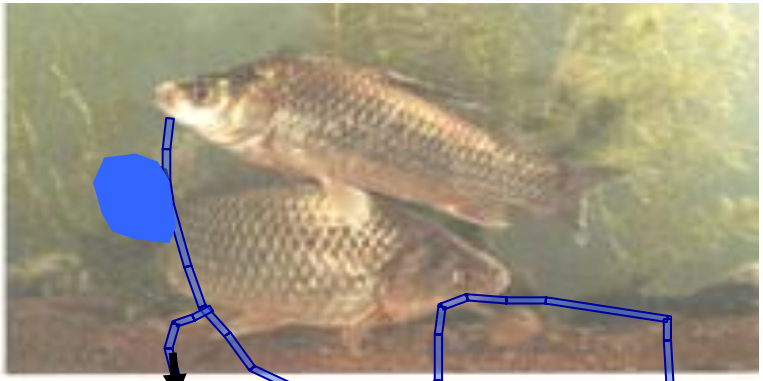


Estrogen of sediment in tian jin river



- **Total amount of sediment in wenyu river: 0.39-36.6 ng/g, most sample points exceed the concentration of control point get in control point（N1）**
- **The concentration of estrogen in water was high, e.g. Dagu sewage disposing river：8.2-51.6 ng/g**
- **It was at a high levels compare to domestic and foreign values.**

Endocrine disrupter in municipal sewage may impact aquatic ecosystem, the egg yolk protein levels of male fish in the water of eliminator downstream rose significantly , hermaphrodite barracuda appeared in heavily polluted rivers



Vtg(ug/ml)

female：2329 ± 462
male：888 ± 827

down
town

WWTP

female：473 ± 530
male：ND

Environmental Contamination and Toxicology, 2006,77; Arch. Environ. Contam. Toxicol. (2004):46, 1–7; J Chromatogr. A. (2002):617-624; Bull. of Environ. Contam. & Toxicol. (2003):527-532

Ecological and health impact of reclaimed water

- **WWTP's discharge of pollutants would change the structure and function of organisms in the river, i.e. the change of ecological communities in both upstream and downstream;**
- **The trace pollutants would lead to a decreasing number of sensitive creatures in the downstream;**
- **The influence of interaction among creatures overweighs the direct impact from the pollutants**

2. China's Conceptual WWTP

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Eco-friendly integrated with the urban development

2. China's Conceptual WWTP

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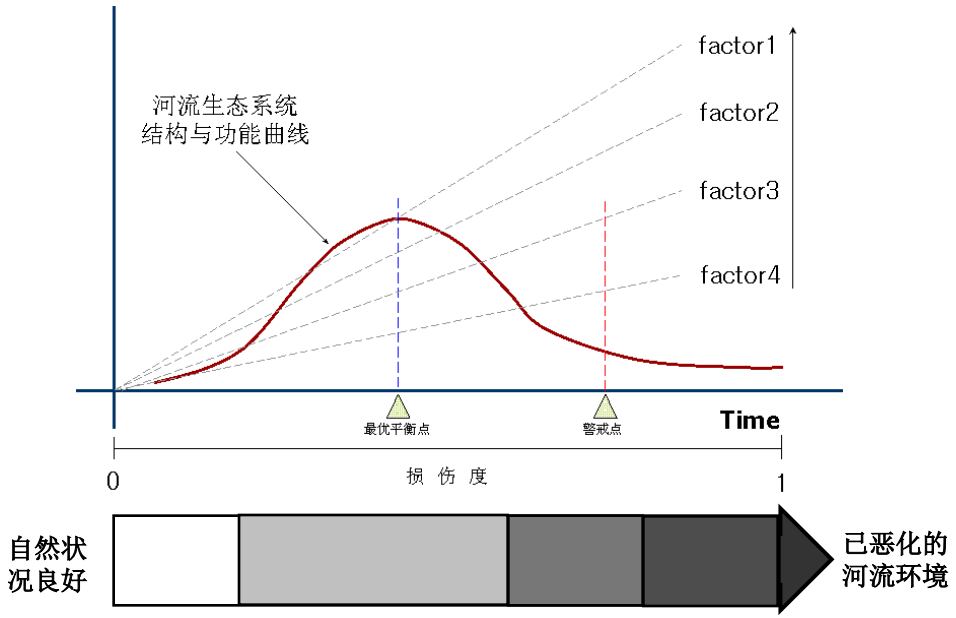
Water ecosystem integrity protection



- Healthy ecosystem
- Minimizing human activity impact on aquatic ecosystem health
- High quality service value of water ecological system for humans

The best policy and measures to guarantee water ecosystem health

3. Our visions

★ **A future-oriented systematic exploration**

★ **A visionary prediction for the wastewater treatment process in the coming 20 years**

★ **Trendsetter for the mainstream technologies in the future in China**

3. Our visions

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One-step Realization

For the future

20-30 years

Advanced Concept & Technology

Intelligentization

Optimal Integration

3. Our visions

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Creating economic values through the progress

- **Extend the ideas of the conceptual WWTP**
- **Optimize the conceptual design**
- **Integrate with the latest technologies**
- **Innovate the operational model**

4. Our Schedule

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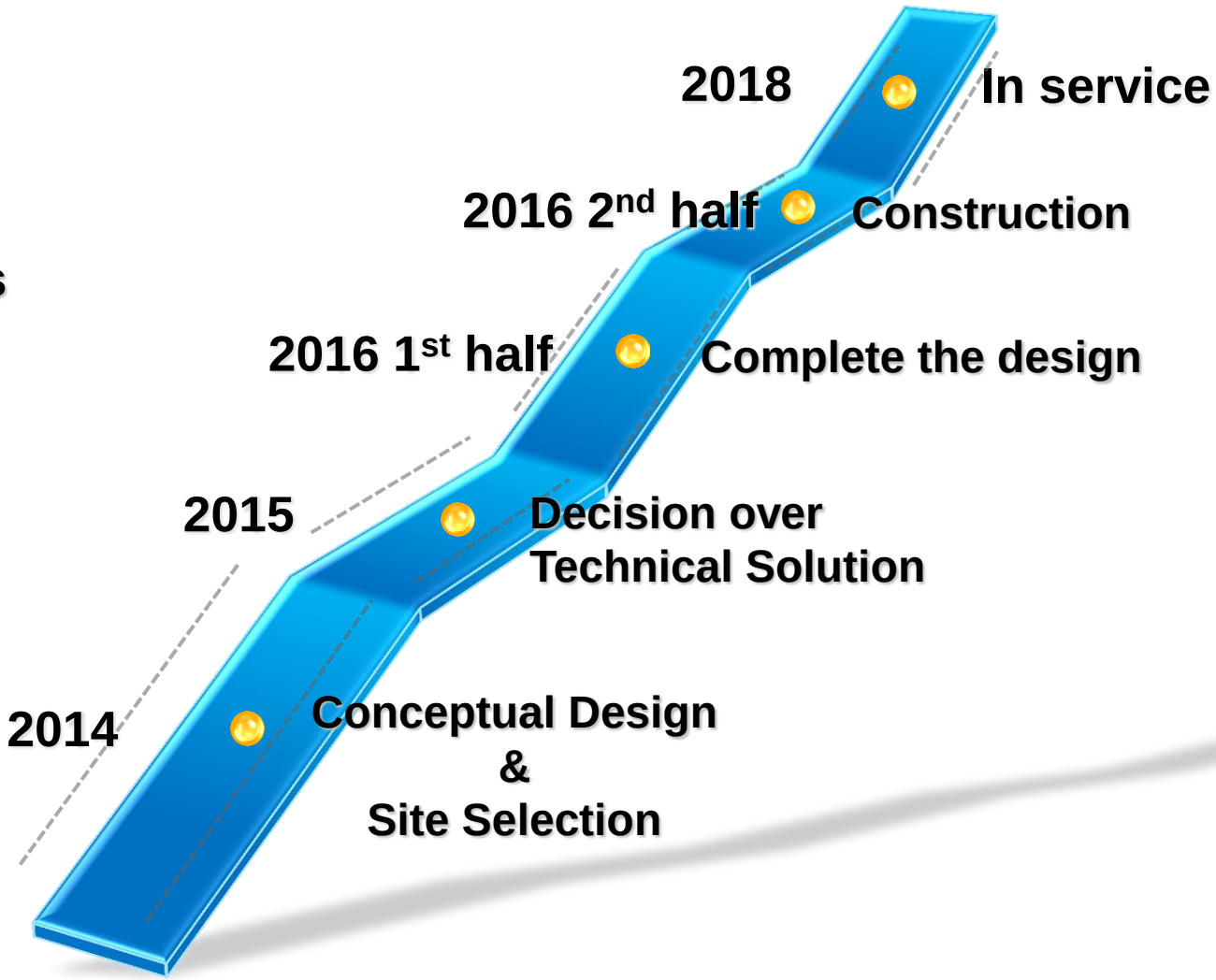
Schedule:

Start： 2014

Duration： 5 years

Plants： 1 - 3

Finish： 2018



4. Latest Progress

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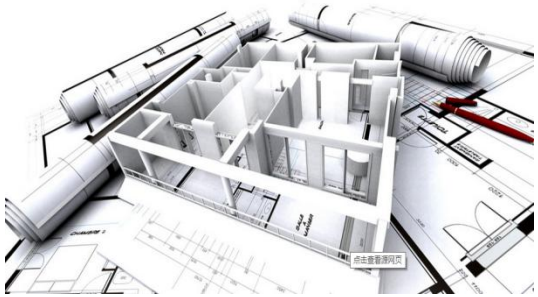
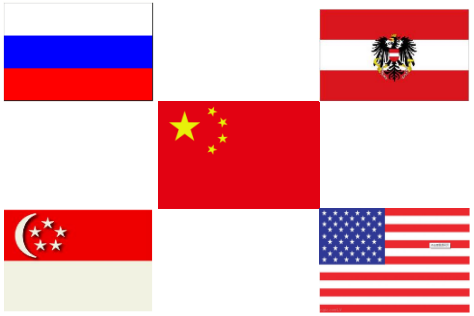
Objective 2014:



Concept Design

Site Selection



International Exchange

My idea on the CWWTP in China

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The CWWTP will be implemented in the modification of the old plants and the construction of the new plants.

More important:

Not only build one or more wastewater treatment plants, but also introduce the new concept, new technology, new management model in China.

Thank you!

Suggestions?