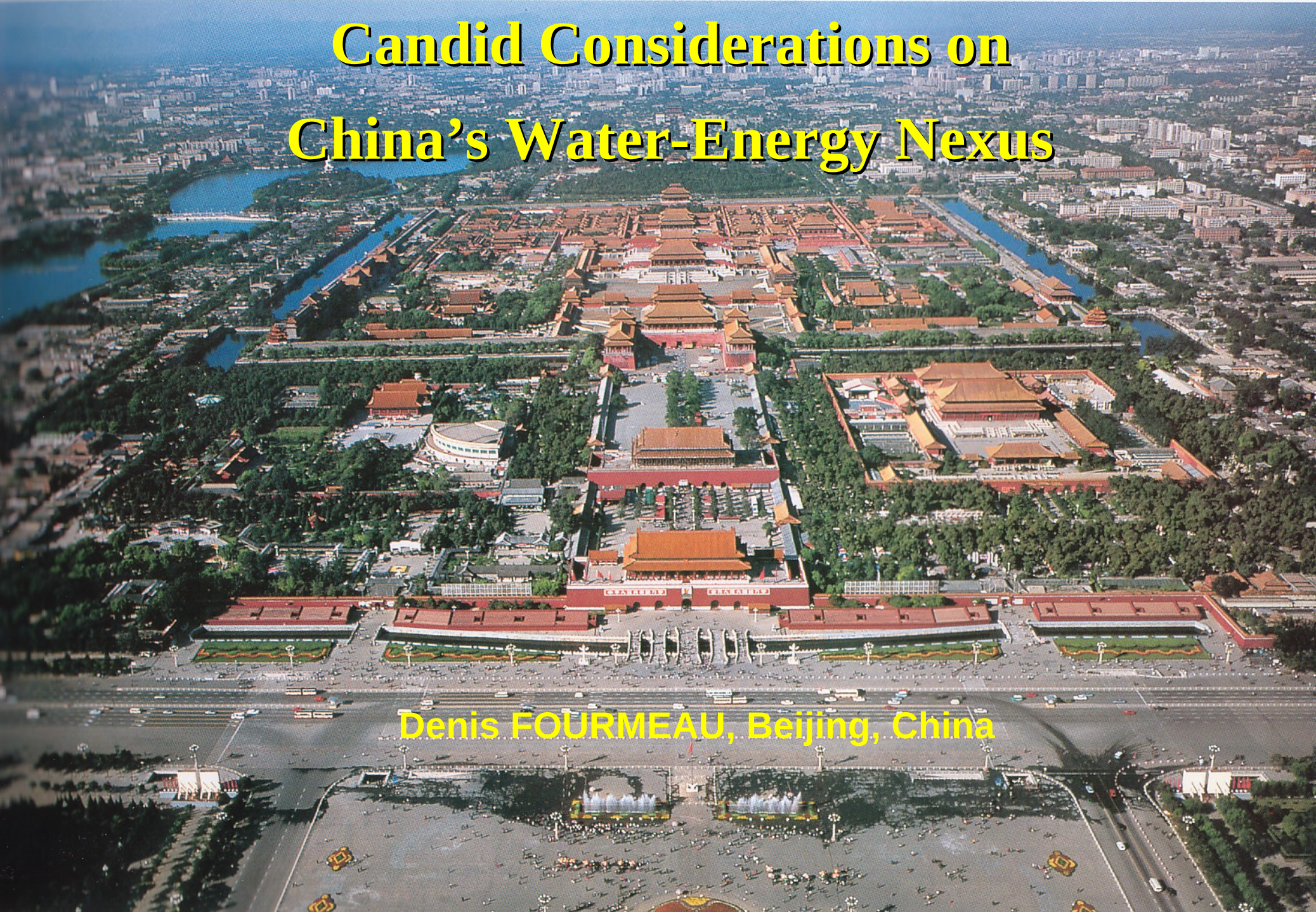
Candid Considerations on China's Water-Energy Nexus

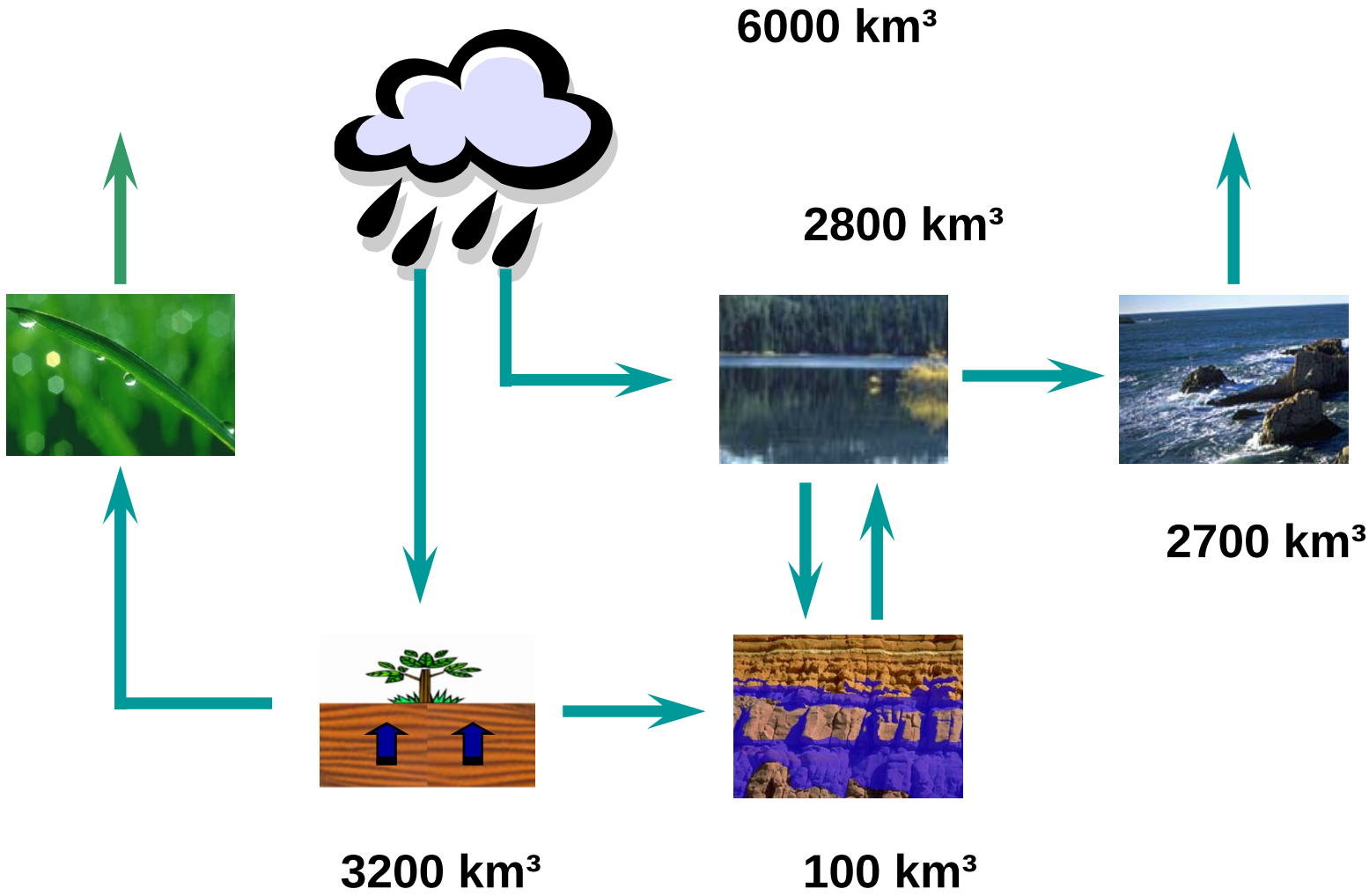


Denis FOURMEAU, Beijing, China

Infomercial n°1

- Morocco 1990-1993: bilateral cooperation on infrastructures (water, energy): no oil, not much water either, first attempt to set up water agencies
- Jordan 1996-2000: no oil and no water, inextricable nexus (20% of electricity used for pumping water!), emerging recognition of virtual water issues. Main lesson: scarcity leads to cooperation, not to conflict.
- IOWater-INBO 2000-2006: work with WWC, virtual water on the agenda, but mostly agricultural focus
- EU Delegation to China since 2007: cooperation in clean energy=> « accompanying China's transition towards a low-carbon economy ». What about low-water economy?

CHINA: total Availability of Water Resources at 2800 km³/year, ranked No. 6 in the World



China's water resources are in a state of crisis

China has:

- **6.2 % of global renewable freshwater (2800 $Km^{3)}$**
- **8 % of global arable land**
- **20% of the global population**

Per capita (theoretically…) available water:

- **2002: 2200 m^3**
- **2030: 1700 m^3**

Much less (500 m^3) in some parts of North China

China is already a water-stressed country !

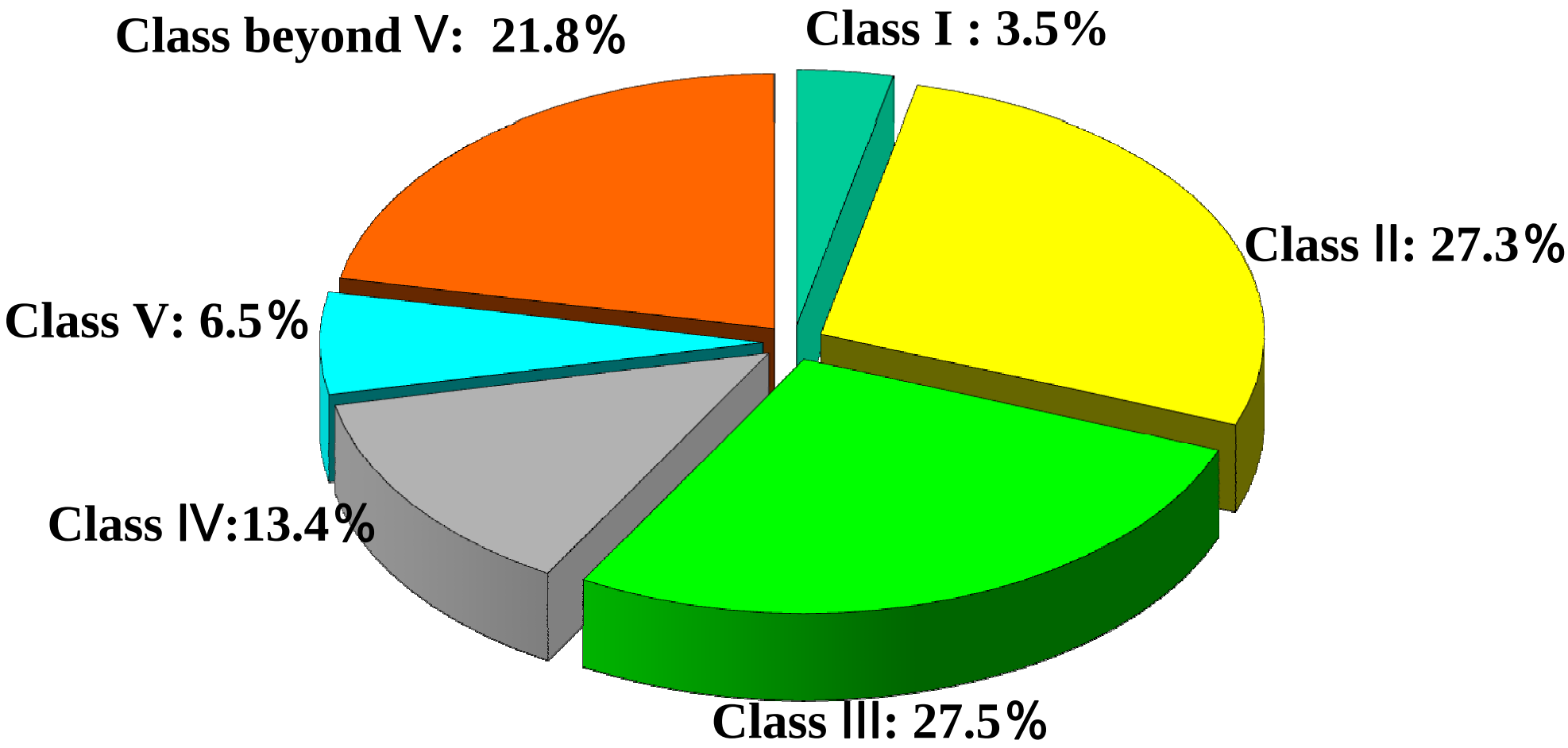
Water Security in Asia

- **The source of Asia's major rivers are in China**
  - Mekong: Myanmar, Laos, Thailand, Cambodia, Vietnam
  - Brahmaputra: India, Bangladesh
  - Nu Jiang (Thanlwin): Myanmar
  - Senge Zanpo (Indus): Pakistan, India
  - Hong He, (Red River): Vietnam
  - Irtysh: Kazakhstan, Russia
  - Heilong Jiang (Amur): Russia

When China gets thirsty, Asia gets thirsty!

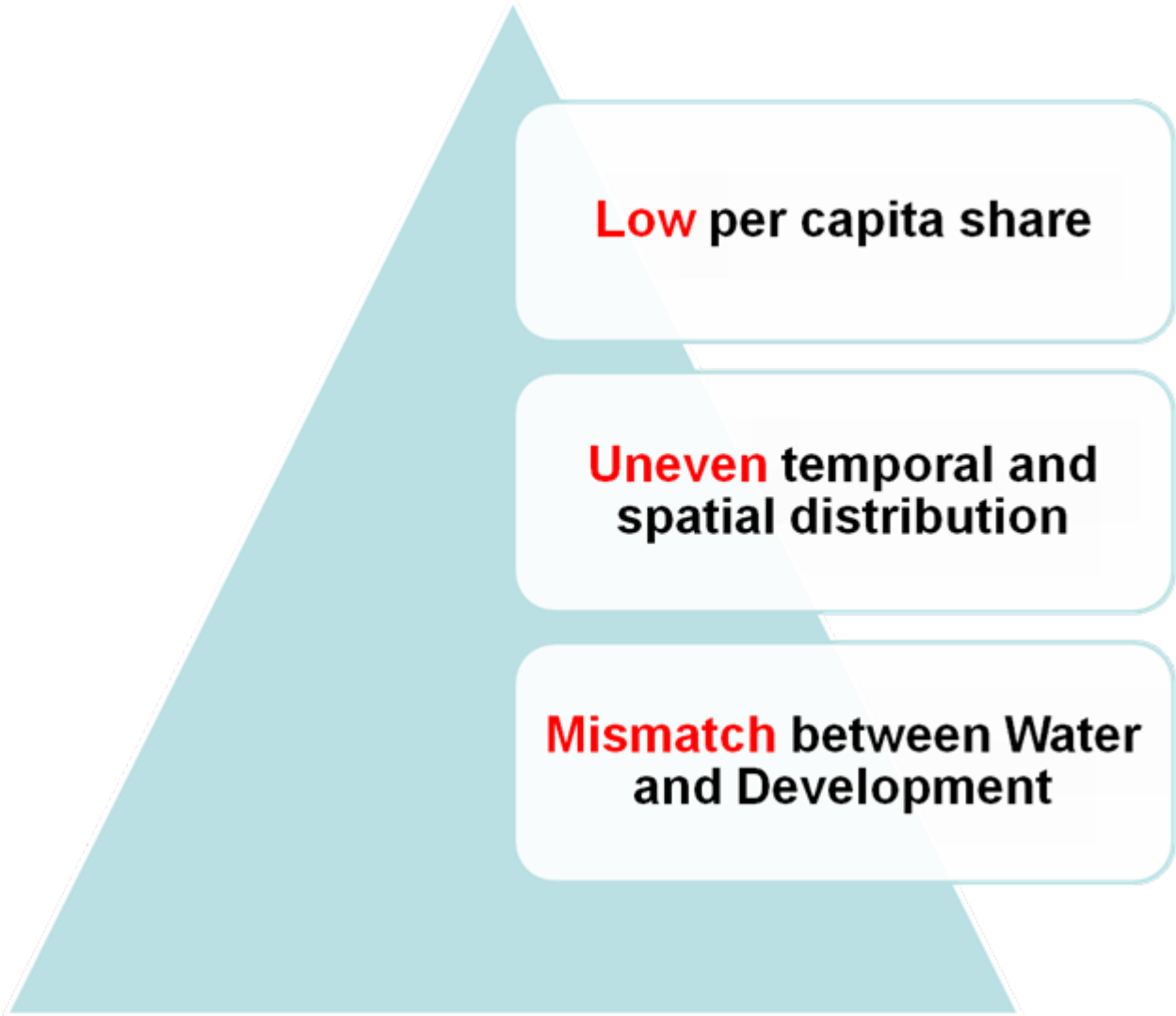
In addition:

WATER POLLUTION THREATENING WATER AVAILABILITY
only 30% actually available (water quality class 1 or 2)

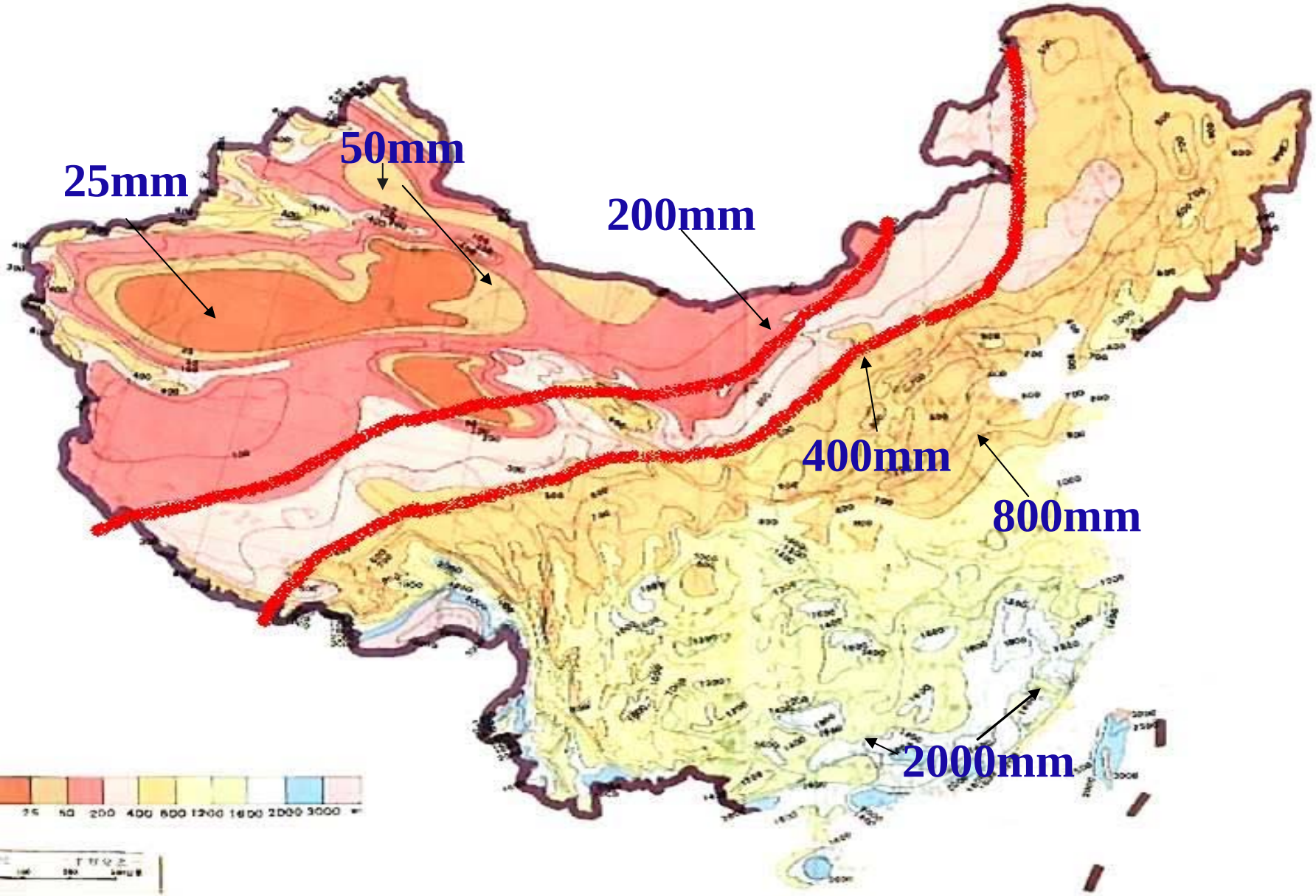


The result of the water quality assessment in 2006 with regard to a total river length of 138,000 km.

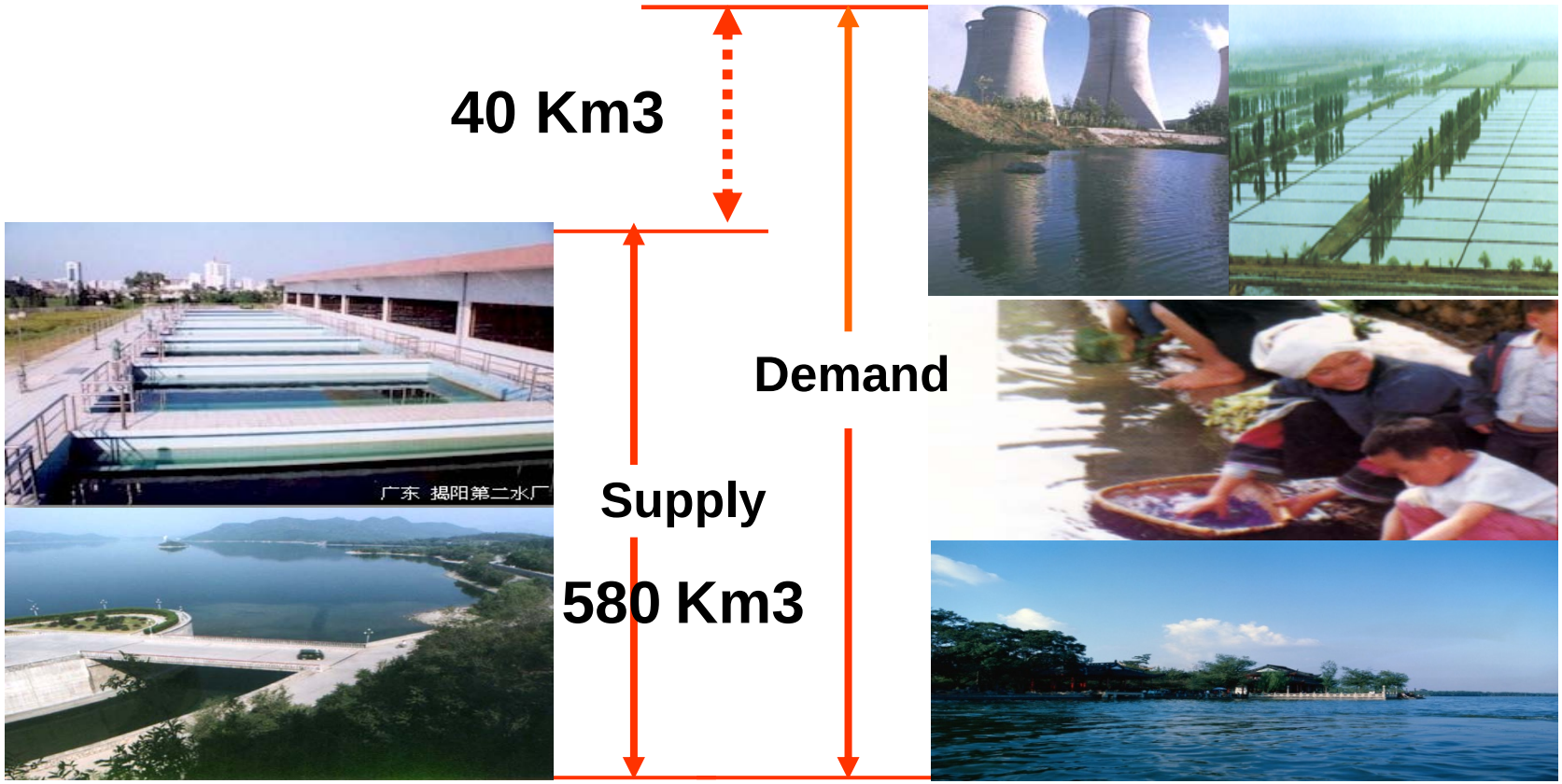
Major Characteristics of Water Resources in China



Uneven Spatial Distribution of Water, Progressively Increasing Rainfall from North-West to South-East



Annual Water Shortage in China



Deficit 40 Km3 (in 2007)

1.6 billion

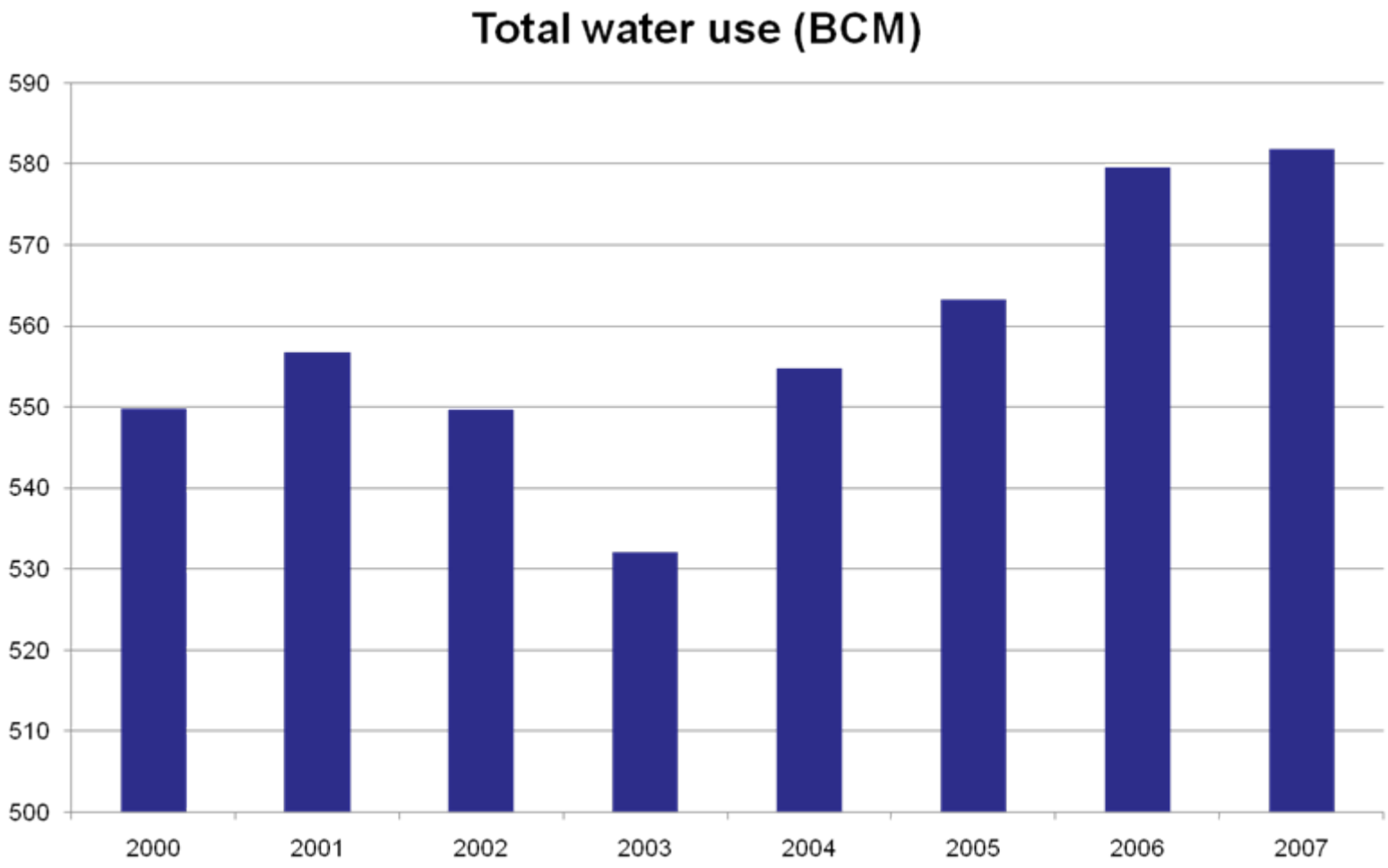
by 2030

A Looming Crisis

Demand 700-800 Km3

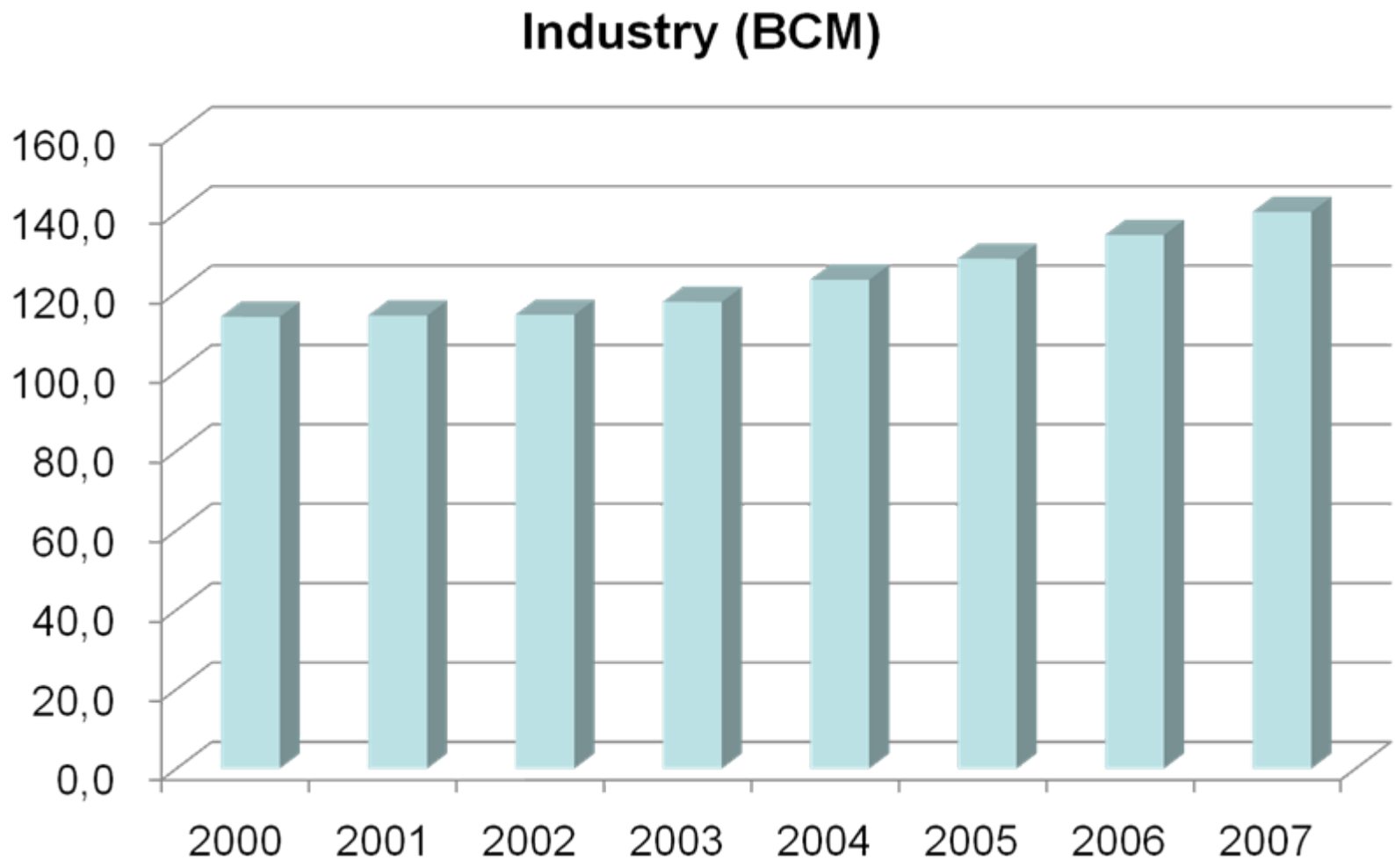
Exploitable Resources 800-900 Km3

Continuing Growth of Water Use

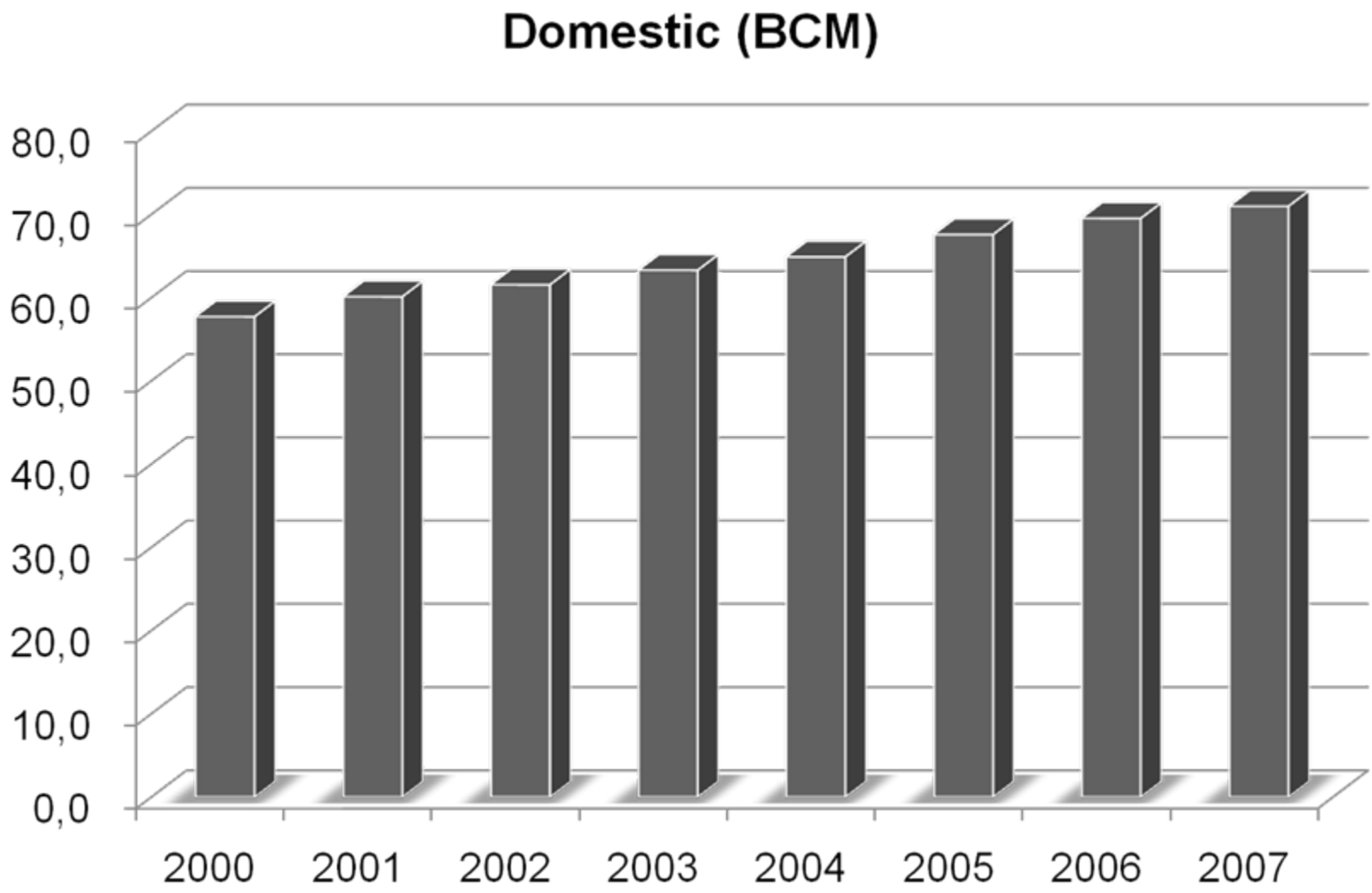


Source: Ministry of Water Resources Annual Report - unit: Km3

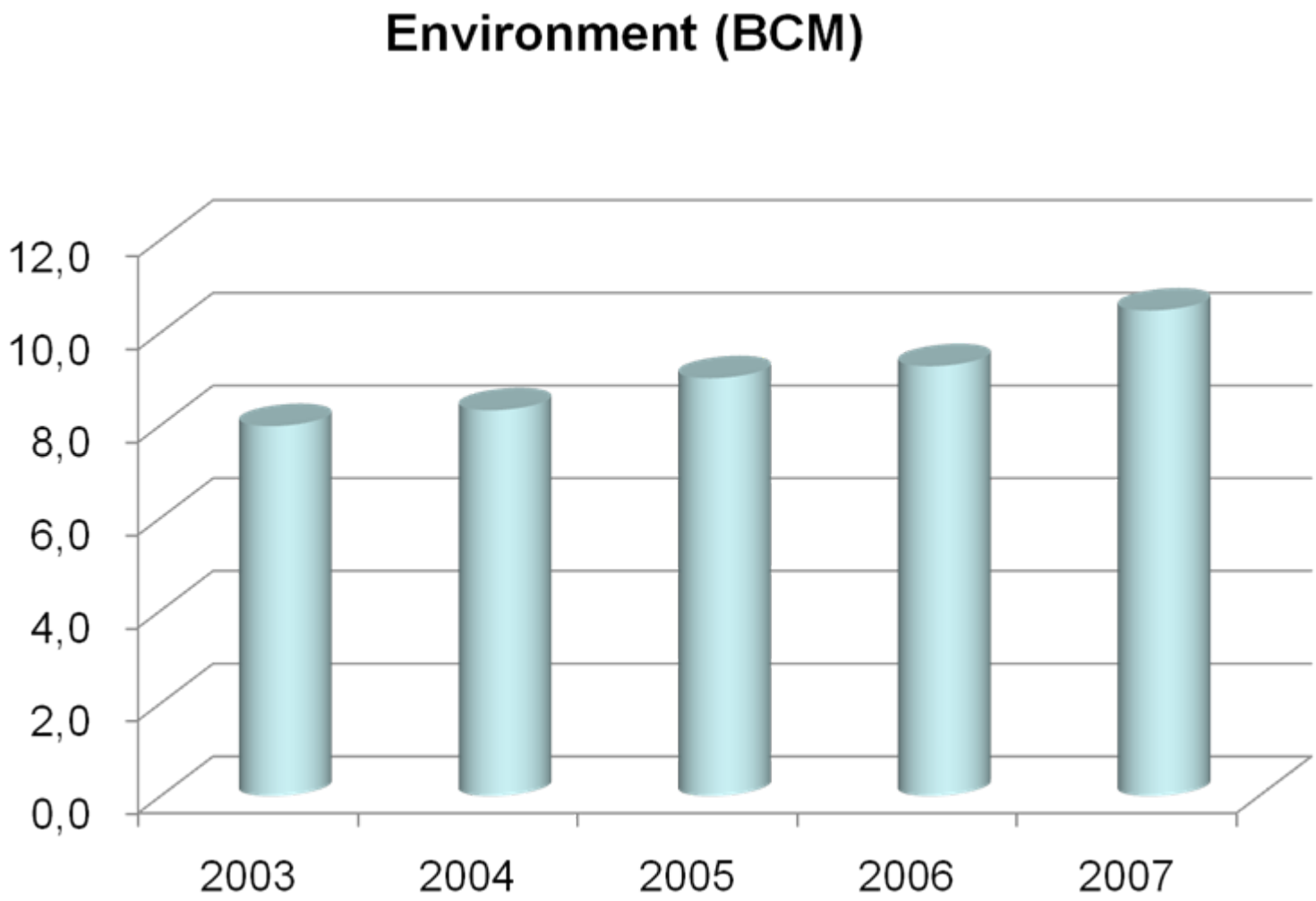
Mainly due to Industrial Demand



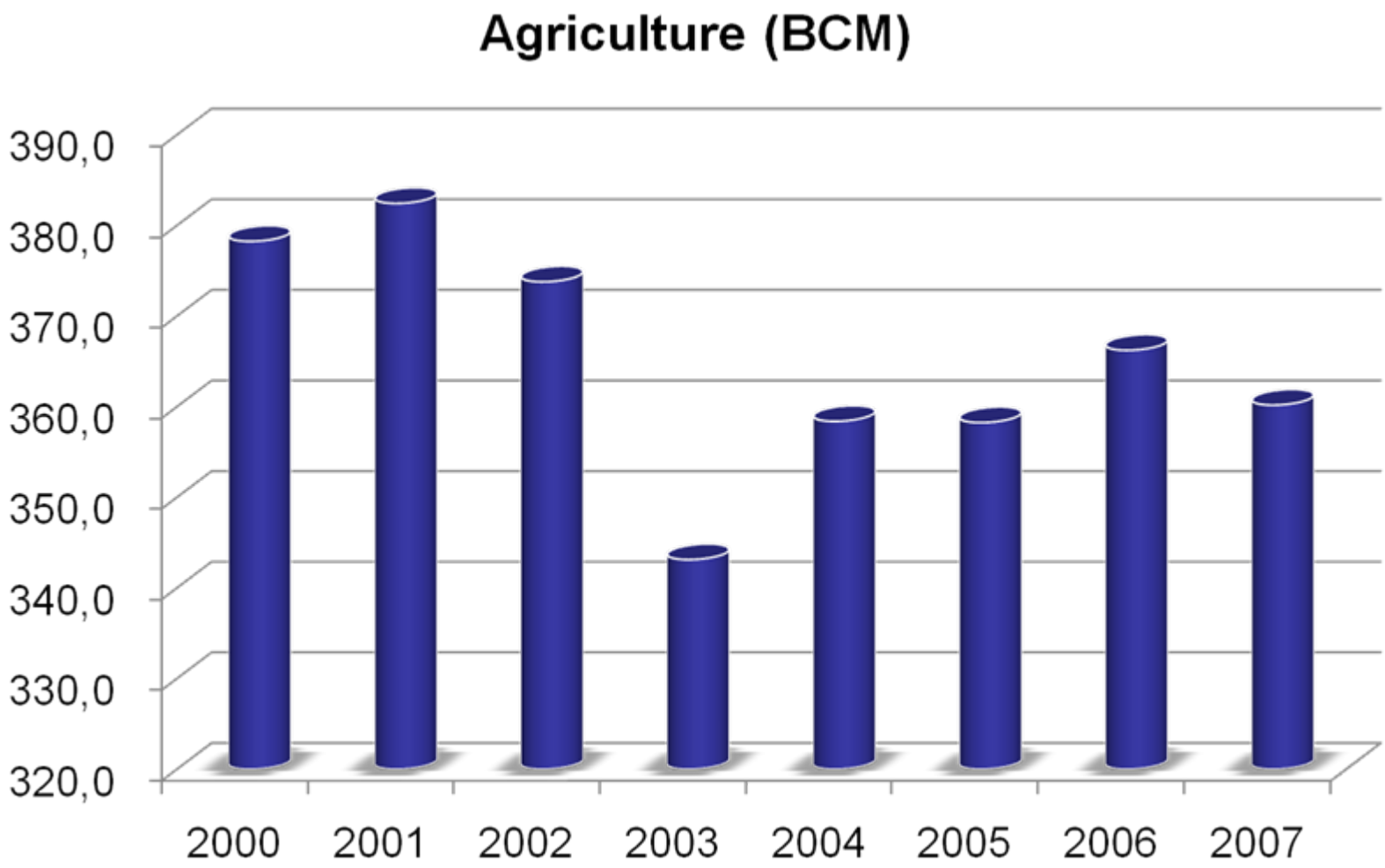
and Domestic Requirement



Also this: “Good start!”



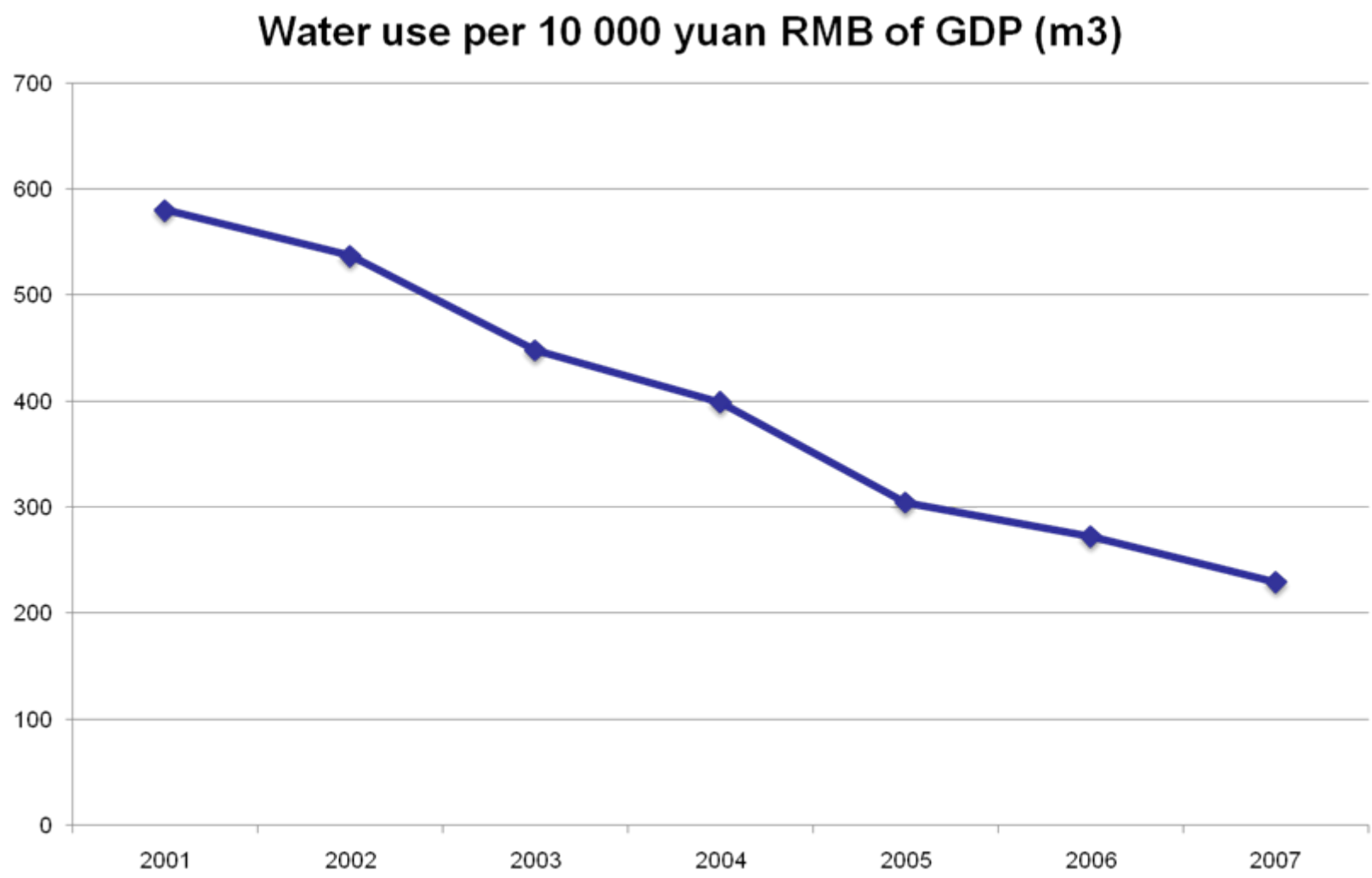
Still the biggest user…

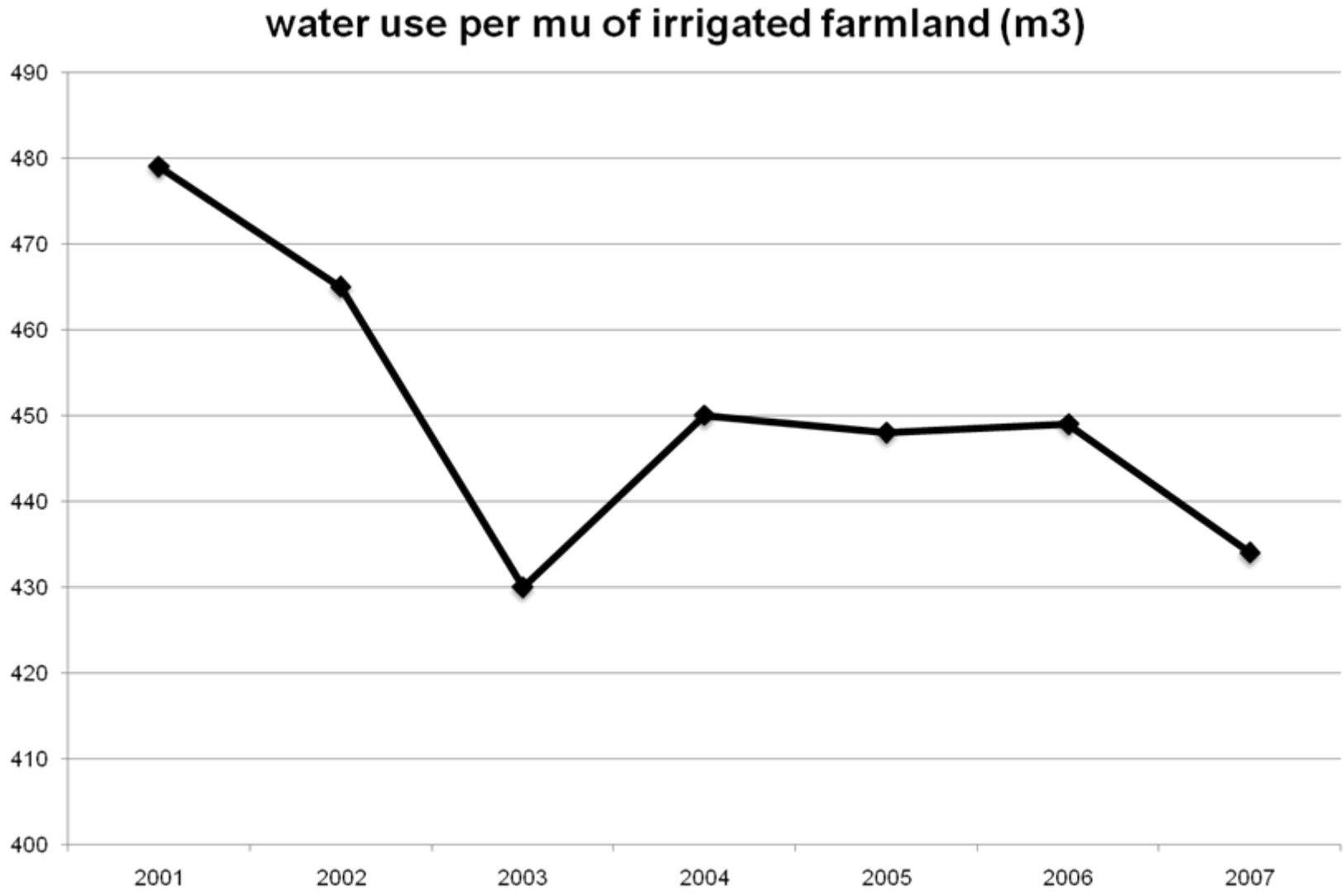


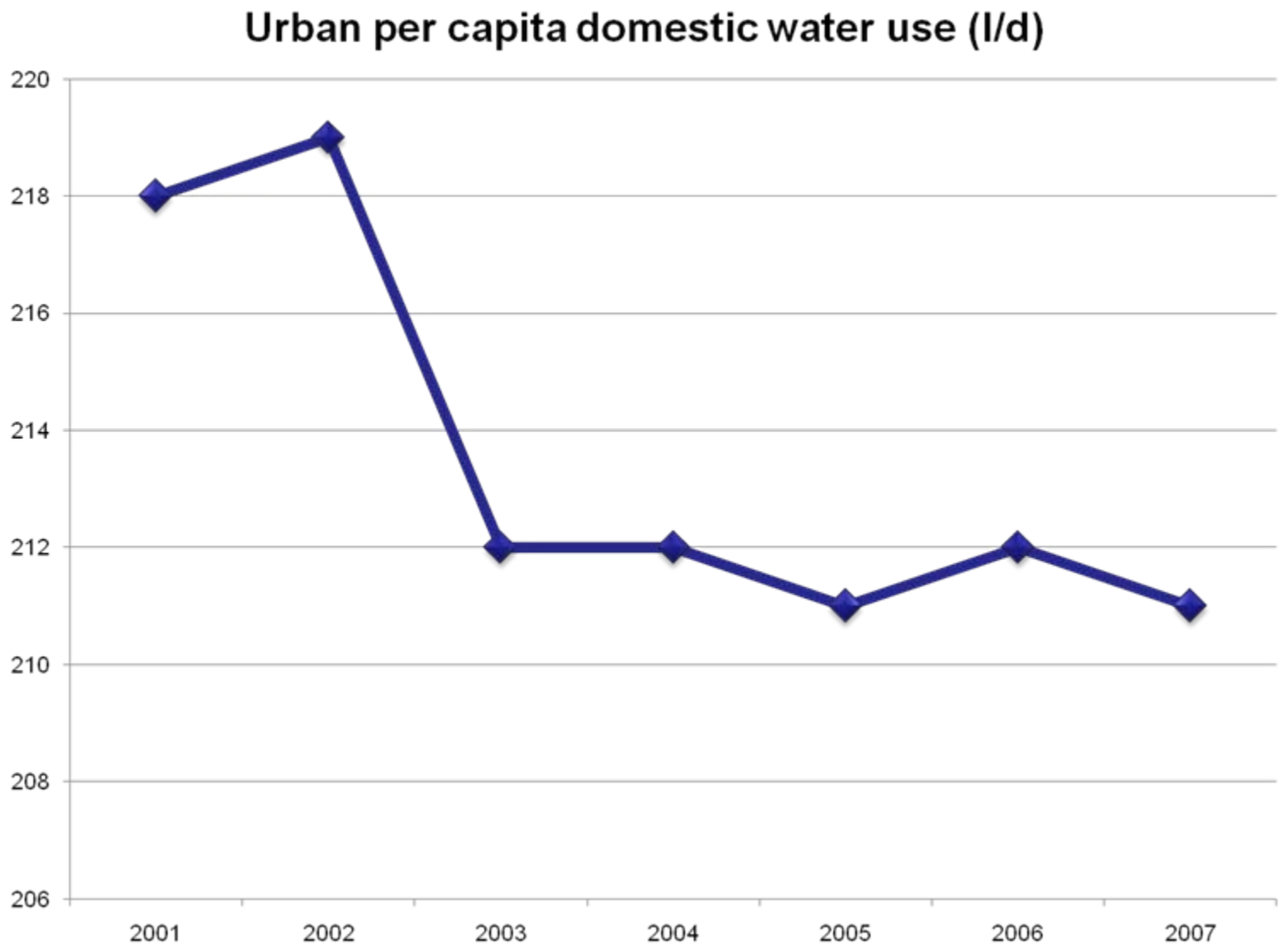
Some encouraging indicators

- Water use per 10,000 yuan RMB of GDP (about 1000 Euros)
- Water use per mu of irrigated farmland

  (1 mu = 1/15 hectare)
- Urban per capita domestic water use


Water use per 10 000 yuan RMB of GDP (m3)
700
600
500
400
300
200
100
0
2001
2002
2003
2004
2005
2006
2007


water use per mu of irrigated farmland (m3)
490
480
470
460
450
440
430
420
410
400
2001
2002
2003
2004
2005
2006
2007


Urban per capita domestic water use (l/d)
220
218
216
214
212
210
208
206
2001
2002
2003
2004
2005
2006
2007

The « intensity approach »: a water-energy parallel…

Water – 2006-2010-2020

20 % reduction in water intensity (water consumption per unit of GDP) compared to 2005 in current FYP 2006-2010

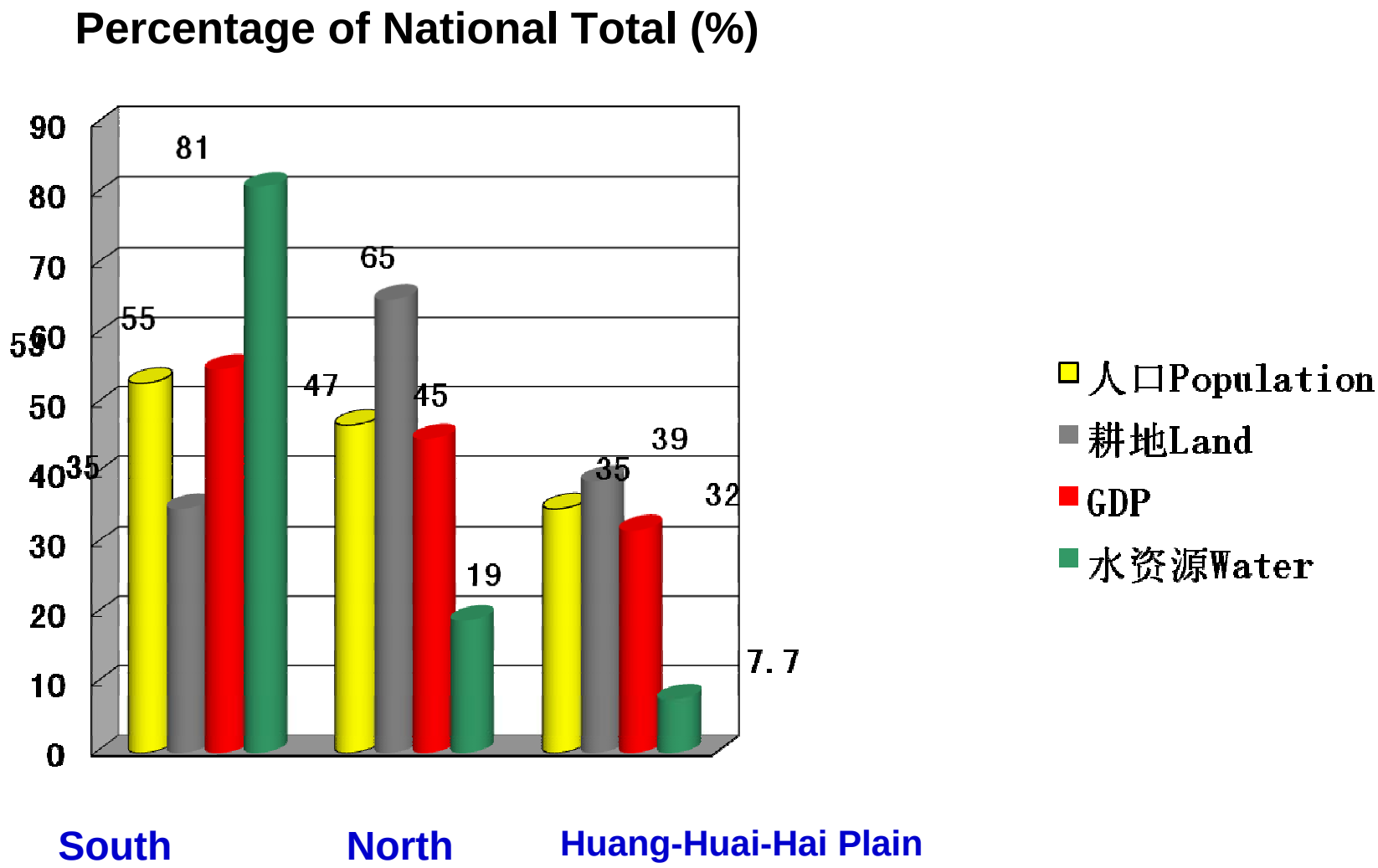
RECENT NEWS 02/2009: 60% reduction in 2020 compared to 2005 !!

Energy – 2006-2010-2020

- 20 % reduction in energy intensity (energy consumption per unit of GDP) compared to 2005 in current FYP 2006-2010 + specific program targeted at 1000 largest enterprises
- **BREAKING NEWS 26/11/2009: 40% reduction in 2020 compared to 2005 !!**

… TO COPE WITH PARALLEL STRUCTURAL MISMATCHES

Mismatch n°1: Water Resources vs Domestic, Agricultural, and Industrial Consumption



Energy Resources vs Consumption: Coal and Hydro: Mismatch n°2 & 3

Coal production

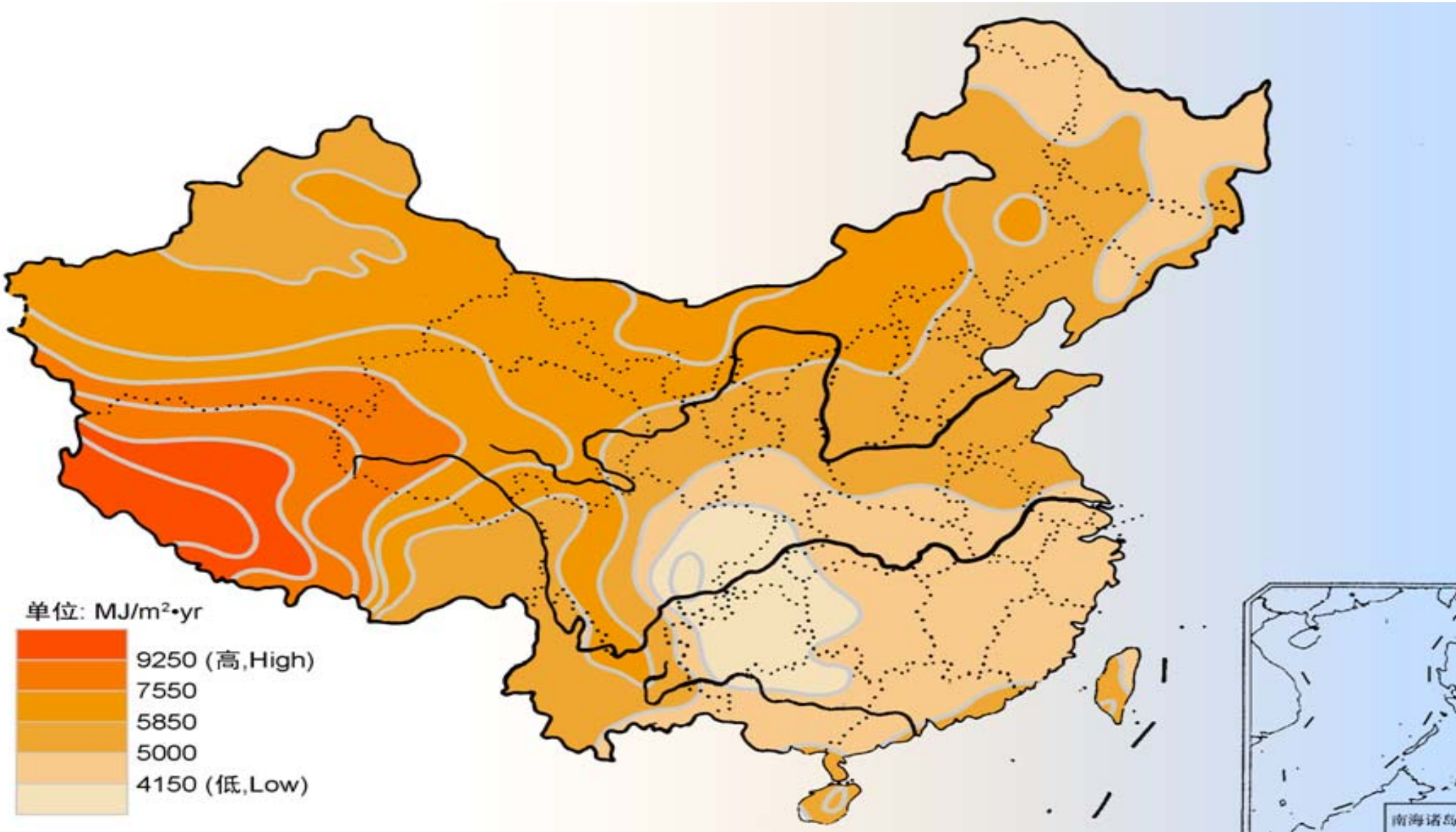
Hydroelectricity potential

Consumption

Three Gorges Project

Completed this year after 13 years construction
1 million people resettled

Energy Resources vs Consumption: Solar: Mismatch n°4



Energy Resources vs Consumption: Wind: Mismatch n°5

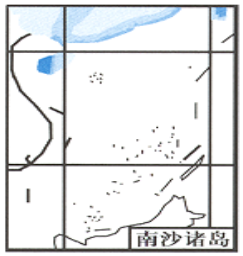


图3 中国有效风能密度分布 (w/m²)

Figure3. Distribution of effective wind power density in China(w/m²)

中国气象科学研究院

Chinese academy of meteorological science

200瓦/平方米以上 (High)
150——200 瓦/平方米
100——150 瓦/平方米
50 ——100 瓦/平方米
50 瓦/平方米以下 (Low)

Potential:

On-Shore: 250 GW

Off-Shore: 750 GW

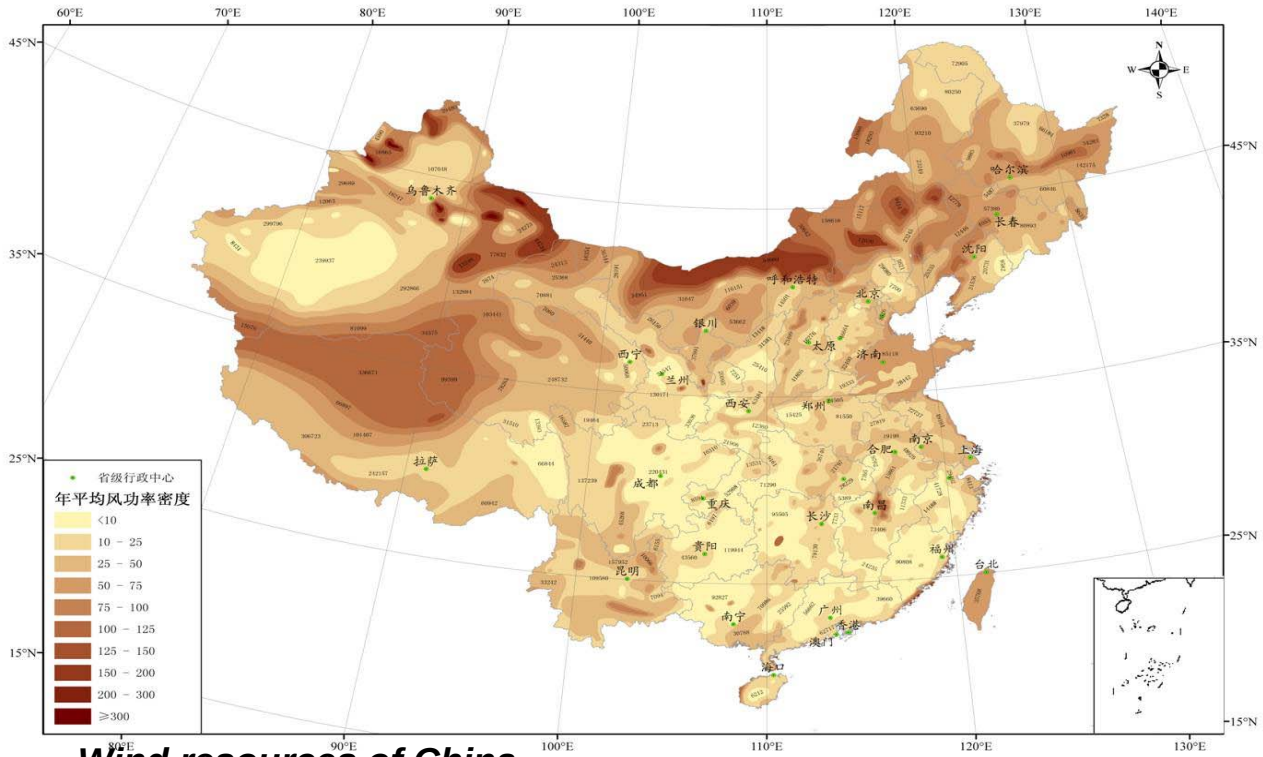
Infomercial n°2 (NB: courtesy of VESTAS)

“Wind saves Water, in water-stressed areas … and wind is abundant in China where there is little water”

Wind energy consumes considerably less water than other energy sources…

120 GW of wind energy instead of coal energy would **save >630 million m³ of water**

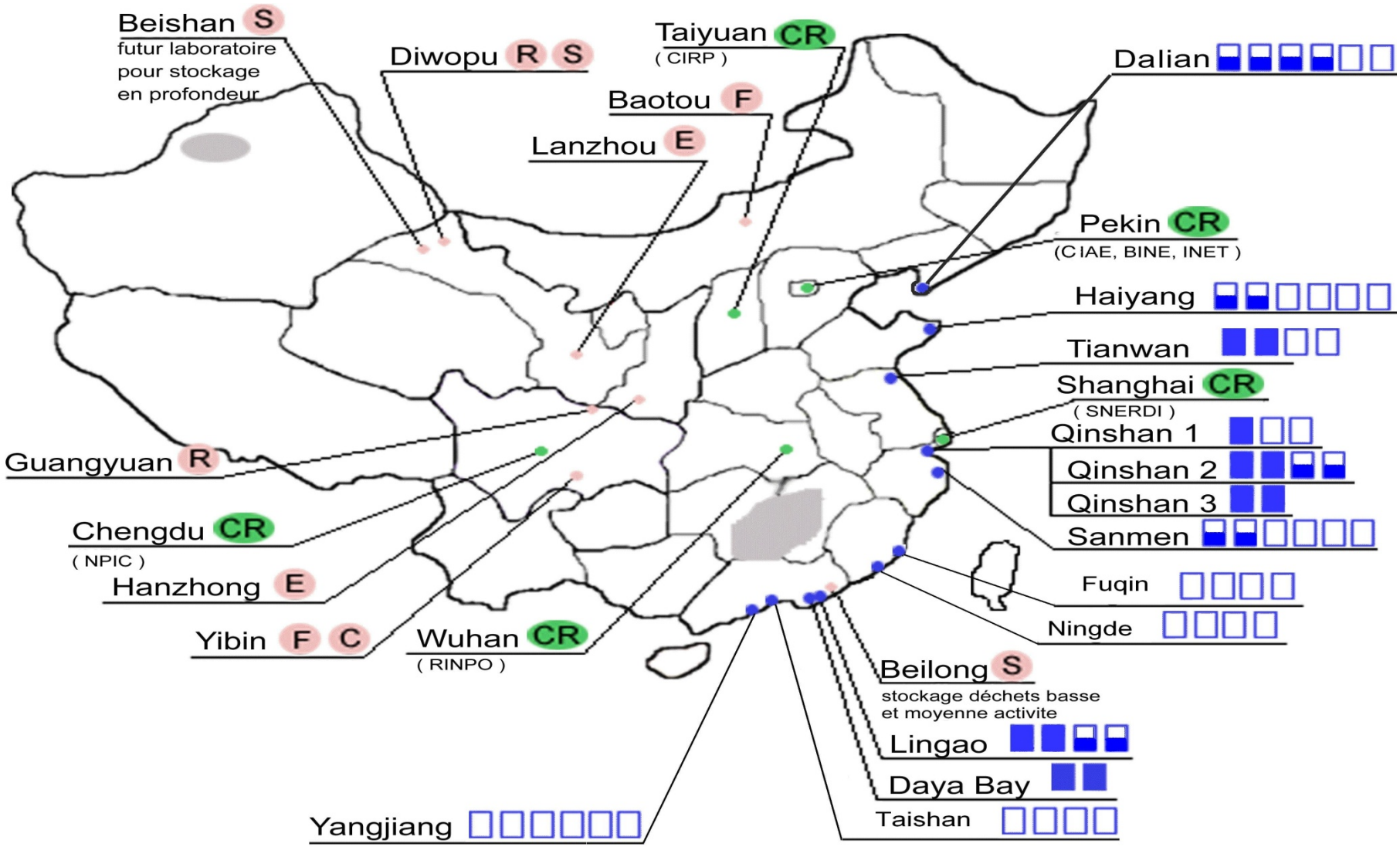
(NB: Source: VESTAS)



Wind resources of China

(NB: Same can be said for Solar Energy…)

Production vs Consumption
Nuclear - a perfect match ???



Water Footprint

5th World Water Forum, March 2009

Topic 2.2 “water for energy, energy for water”:

“As the science of water footprints as applied to energy options still is in its infancy, topic participants agreed to advance and intensify research in this area.”

For energy: based on water consumed for

- Production/extraction of raw materials
- Refining raw fuels
- Producing energy at a power plant

NB: consumed=withdrawn which is no longer available for use (definition of European Environment Agency)

Coal impact starts from the mine!

- 2007 output: 2 550 M tons (largest in the world, ahead of USA 1070 M tons)
- Proven reserves: 1 000 Billion tons
- Shanxi, Shaanxi, Inner Mongolia, Xinjiang: 74 % of coal reserves, 1,6 % of water resources!
- Washing: 4 to 5m3 per ton of coal, 1/3 of output washed

=> 4 km3/year, heavily polluted wastewater (metals, sulphur, salts, low PH…)

- Also: lowering of water tables, water used to suppress dust in open storage…(*no data on this*)

Sources: Cleaner Coal in China, IEA 2008
The True cost of coal, Greenpeace /WWF/ Energy Foundation 2008

Water Footprints (virtual water): some everyday examples

Product	Water consumed (liters)
1 glass beer	75
1 cup coffee	140
1 glass milk	200
1 liter bio-ethanol (corn)	1200

The good news: drink beer, not milk!

1 cotton T-shirt	2000
1 hamburger	2400
1 pair leather shoes	8000
1 kg of beef meat	13500

Source: DHI, IWMI

ENERGY PRODUCTION WATER FOOTPRINT

Source:	DHI (DK)	UNESCO-IHE
Energy Type	**Water consumed (m3/MWh)**	
Wind	0.001	~0
Gas	1	0.4
Coal	2	0.6
Nuclear	2.5	0.3
Oil/Petrol	4	4
Hydropower	68	80
Bio-fuel (corn, US)	184	66
Bio-fuel (sugar, Brazil)	293	90

Key-Features: Mid and Long-Term RE Dev. Plan 2006-2020

	2010 Water footprint	2010 (Target)	2020 (Target)	2020 Water footprint
Hydro	54 km^3	180 GW	300 GW	90 km^3
Wind	negligible ???	5 GW (35 GW *)	30 GW	negligible ??? TBC
Biomass	???	5.5 GW	30 GW	???
Solar PV	negligible ???	0.3 GW (2 GW*)	1.8 GW	negligible ??? TBC
SWH	???	150 Mio m^2	300 Mio m^2	???
Ethanol	2.4 km^3	2 Mio t	10 Mio t	12 km^3
Biodiesel		0.2 Mio t	2 Mio t	
Pellets	???	1 Mio t	50 Mio t	???
Biogas	???	19 Bn. m^3	44 Bn. m^3	???
COAL	**8.4** km^3	**600 GW**	**1040 GW**	**14.6** km^3
NUCLEAR	**0.2** km^3	**12 GW**	**40 GW**	**0.7** km^3

(Assumptions: Hydro 50% availability, Thermal 80% availability, and with DHI water footprints)

Some food for thought...

- **High water footprint of hydropower: about 10% of total storage capacity ??? (85 000 reservoirs, 550 km^3 storage)**

  (NB: EU estimates* based on evaporation patterns range from 2% in Northern Europe to 5% in Southern Europe)

- **Comparatively, coal (and thermal in general) is not that bad from a water footprint perspective !!**

- **Burning coal uses only twice as much water as washing it!**

- **Although biofuels would still account for a negligible portion of the energy mix (<1%), their water footprint in 2020 would be equivalent to the one of thermal**

- **Risk of trade-off between water and climate protection??? (ex: fossils fuels water friendly, climate costly ??)**

***Ecologic-Institute for International & European Environmental Policy: "EU water saving potential" 2007**

Talking about food...

- **Afterall, nothing more than a temporary (and rather low-efficiency...) store of water and energy for human and animal consumption**

- **Food has not only a water footprint, but an energy footprint as well (fertilizer are usually oil-based, or coal-based as in China)**

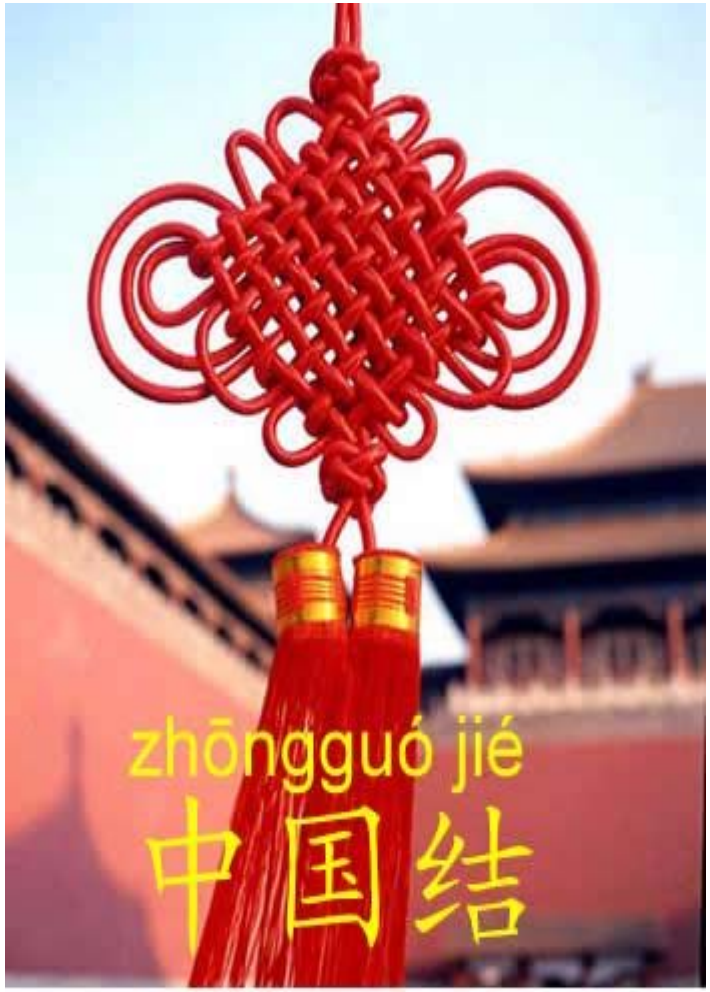
- **In addition: food consumption patterns are changing in China: meat consumption/ capita multiplied by 4 between 1980 and 2005**

(source: Liu (EAWAG) & Savenije (UNESCO-IHE), in Hydrology and Earth System Sciences, 2008)

Talking about land...

- **Food has obviously a land footprint...**
- **Arable land is already scarce (8% of global land for 20% of global population)**
- **…and is decreasing, due to erosion, pollution, water scarcity, and urban development**

The Middle Kingdom: in the middle of an inextricable nexus



Energy scarcity (brownouts today, blackout tomorrow?)

+ Water scarcity (in the 90s, some parts of Yellow River dried up)

+ Arable land scarcity

+ Constant threat of food scarcity…

While demand for energy, water, land and food is continuously increasing!

=> Going to hit the (Great) wall soon?

First approach: increase supply! (1)

- A nation of engineers (cf. “scientific” development):
  mastering the forces of nature
- Classical and easy in a country which has money to spend
  => *“Stimulus package: more infrastructures!”*
- Example: South-North water transfer project:
  65 billion US$ to transfer 45 km^3 annually by 2050
- Aggressive push to secure energy resources abroad
- Opportunity: nuclear with desalination
  1st project under construction in Liaoning
- Threat: Coal to Liquid (Inner Mongolia):
  5 to 10 liters of water per liter of fuel produced.

First approach: increase supply! (2)

- Not only civil engineers but agricultural engineers too:
  mastering the forces of nature again
- The “intensity approach” can also be applied to land:
  decrease in land intensity=increase in land productivity
  => more fertilizers (so more coal)! More GMOs!
- Aggressive push to secure agricultural land abroad
  a recent new trend
- Latest fad: “climate engineering”…

  (Or water theft? Interesting new topic for lawyers and academics)

=>Marginal costs are not yet part of the calculation
(too many engineers, not enough economists…)

Second approach: act on demand!

- The “software” is still lagging behind in China
  (lack of will to implement rather than lack of knowledge)

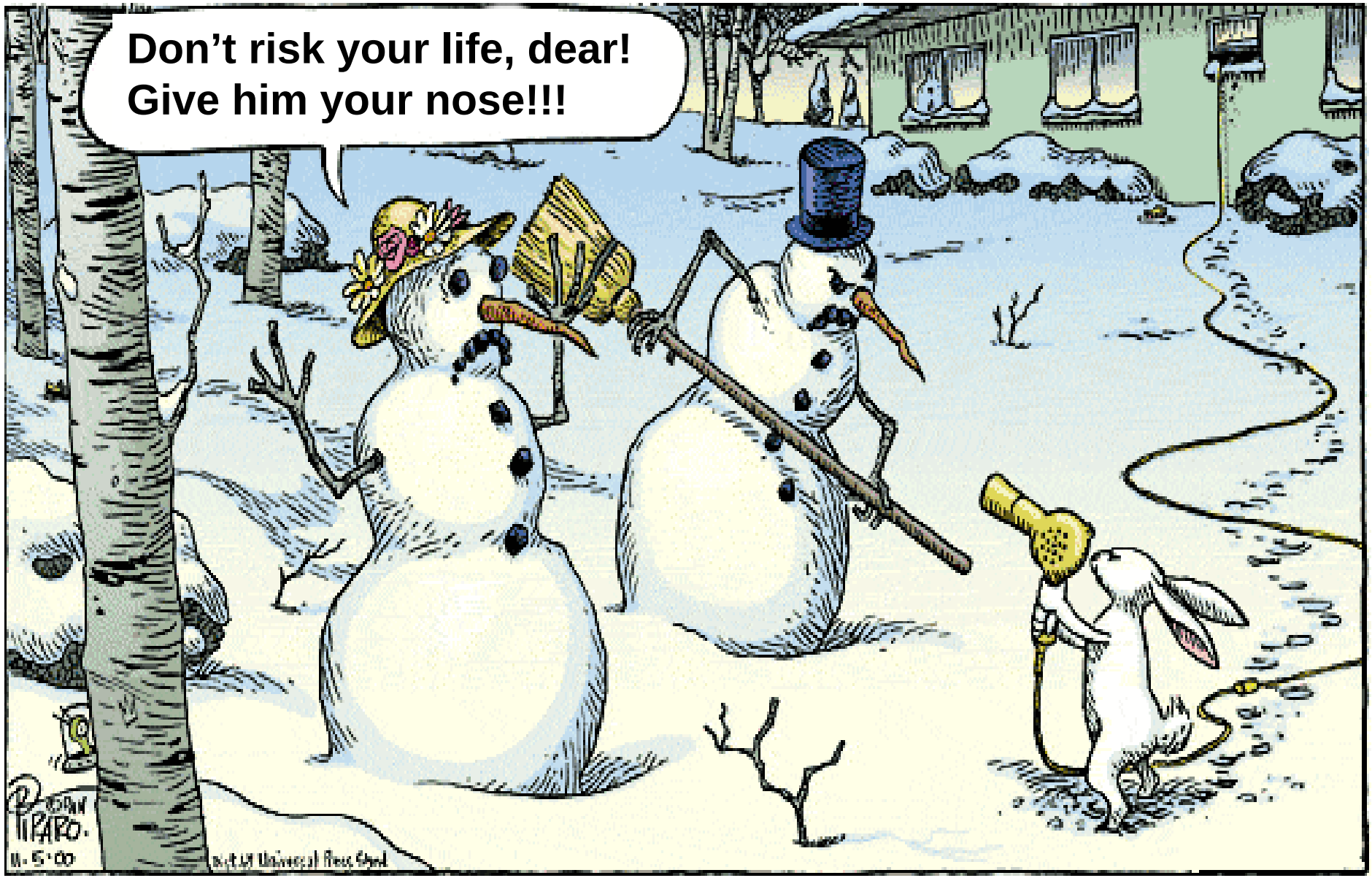
Some encouraging signs however:

- Timid but progressive recognition of externalities
  (cf. WWF report “The true cost of coal”)
- Energy and water prices progressively revised
- Policies on efficiency increase (the “intensity approach”)
- Use of fiscal tools to penalize high energy (water?) consuming industries and products, and encourage “virtuous” ones

Perspectives:

- Market instruments (water allocation mechanisms modelled upon ETS?) a possible and partial answer
- Emerging awareness among (emerging…) civil society
- **Some tough choices (sectoral, political, and therefore societal) ahead anyway…**

=> “A GREEN LEAP FORWARD”??


Don’t risk your life, dear!
Give him your nose!!!
BRIAN PIRARO.
11-5-00