Energy in China: Present and Future

A Brief Introduction

China's Environment Class

Revised November 30, 2011

The basic equation: I = P*A*T

Impact = Population x Affluence x Technology

What will be the impact on China's enviroment for the next 50 years?

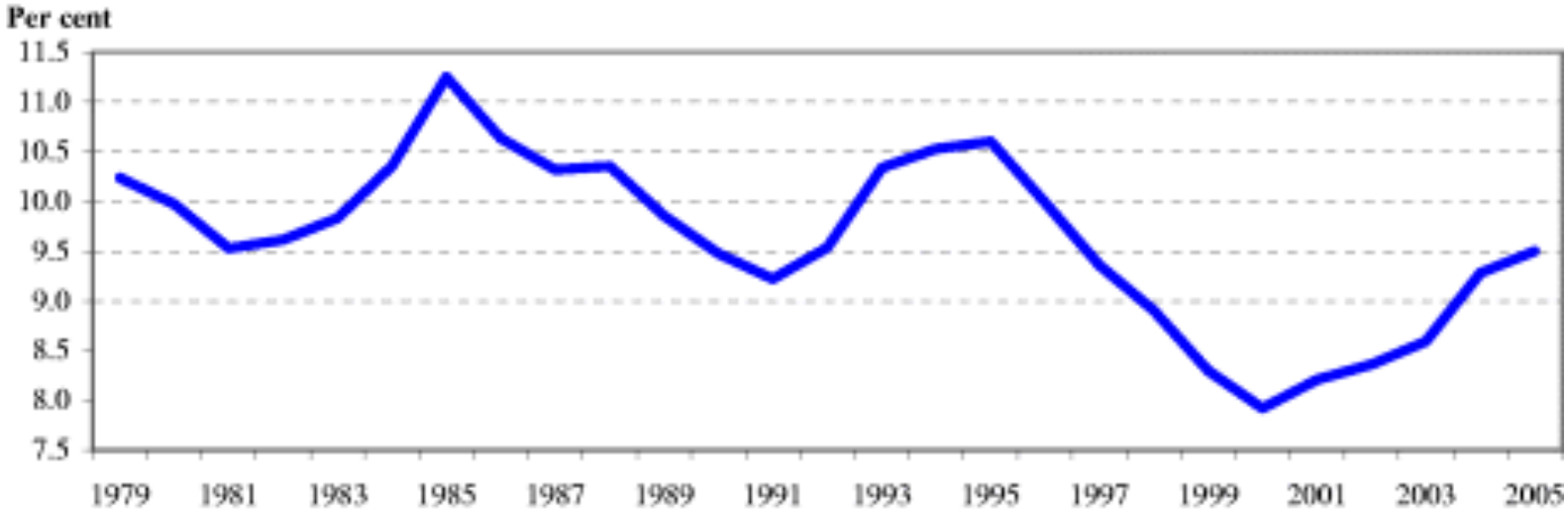
Population will increase slightly, level off, and perhaps decline slightly

Affluence is bound to increase

Technology has room for improvement

Recent Economic Growth

The estimated potential growth rate of the Chinese economy



Note: The potential growth rate is estimated using trend population, participation rates and actual capital stock. These variables are combined using the coefficients from an estimated Cobb-Douglas production function.
Source : OECD calculation.

Economic Survey of China 2005: Key challenges for the Chinese economy, OECD

Projected economic growth

Table 3. Growth Forecasts (average annual growth rates in %)

	Individual variables					GDP			
	Wage (I)	Capital (II)	Wage (III)	Capital (IV)	Labor	Equation (2)		Labor share assumed fixed	
						I+II	III+IV	I	III
2000-05	4.15	6.98	5.18	10.91	0.83	5.80	8.09	4.98	6.05
2005-10	8.18	6.37	6.29	10.85	0.71	7.84	8.83	8.89	7.05
2010-15	7.76	5.63	7.81	10.75	0.20	7.06	9.42	7.96	8.03
2015-20	6.36	5.40	11.79	10.71	-0.80	5.50	10.85	5.56	10.90
2020-25	4.63	4.14	14.22	10.54	-0.62	4.06	12.02	4.01	13.51
2000-25	6.20	5.70	9.01	10.75	0.06	6.05	9.83	6.26	9.07
Cumulative:									
2000-25	350.04	299.69	763.49	1184.75	1.58	333.77	942.78	356.58	777.14

China's Economic Growth 1978-2025:
What We Know Today about China's Economic Growth Tomorrow

By

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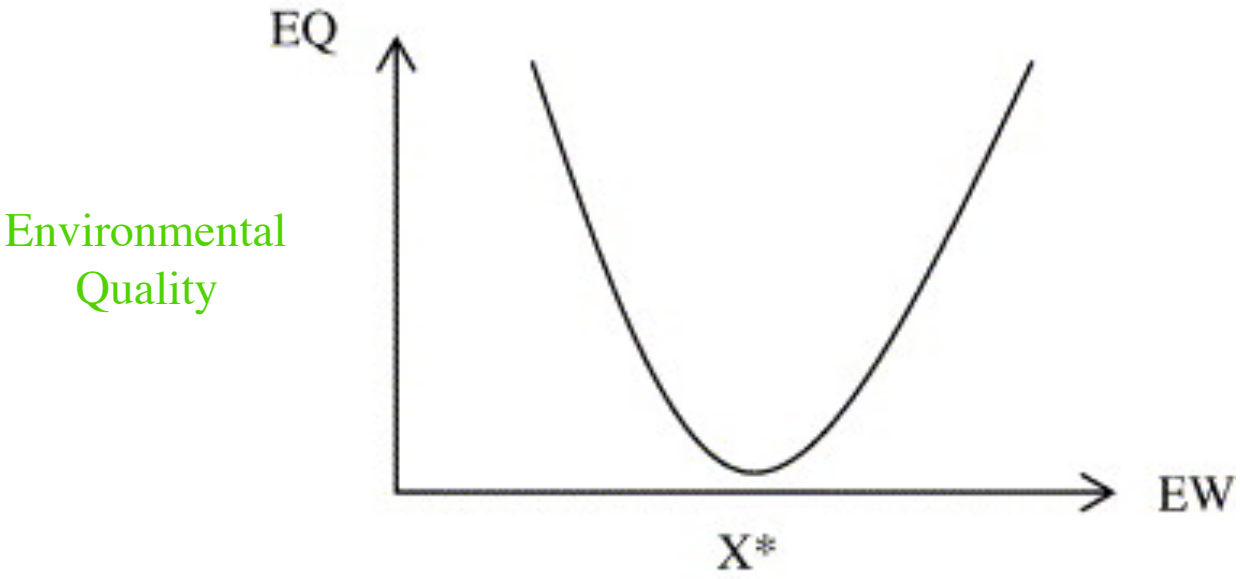
Hong Kong University of Science & Technology

The Other Side of Affluence: Does the Environmental Kuznetz Curve Work?



Energy as a Resource: Supply and Sustainability

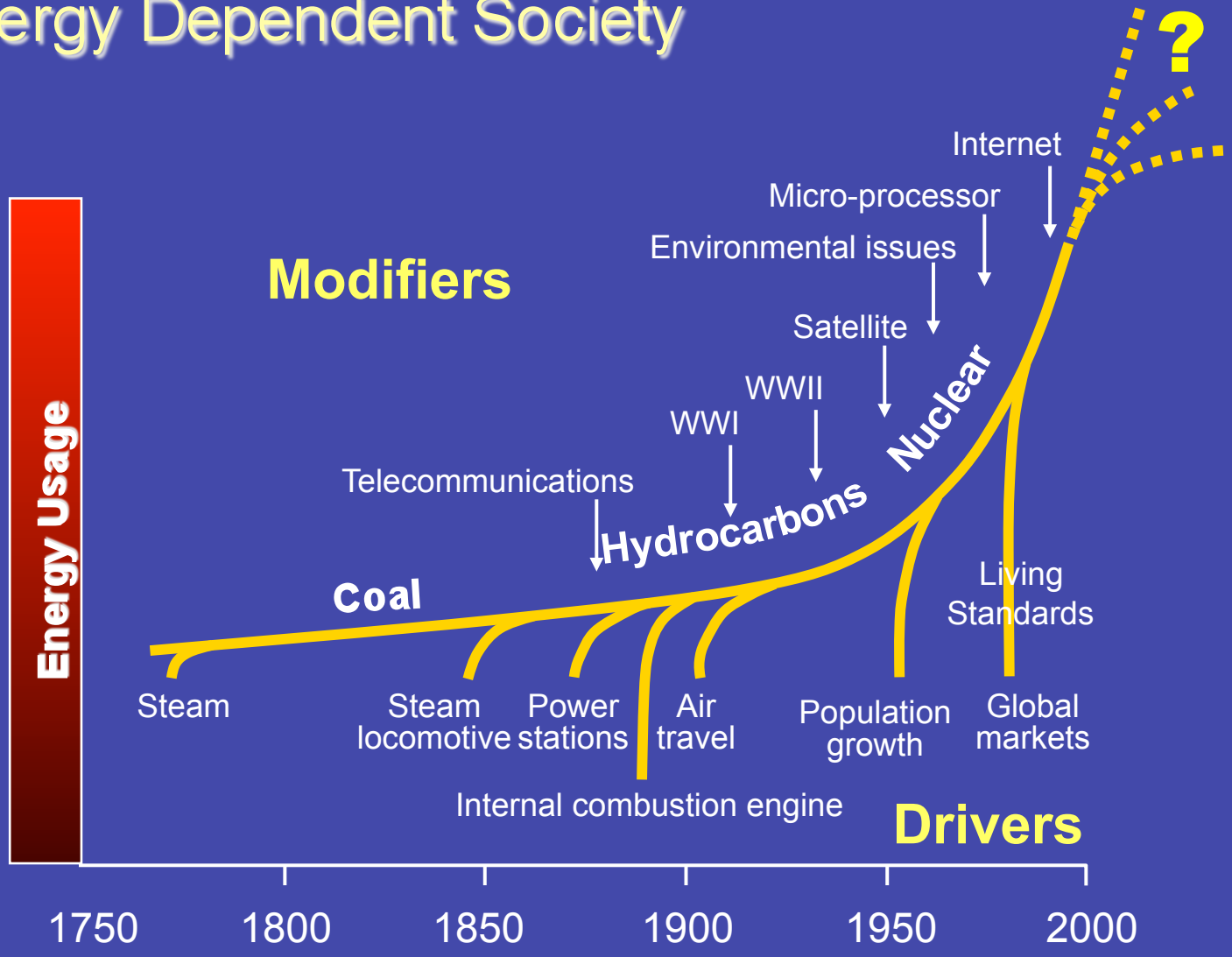
- Water
- Energy
- Forests
- Agricultural Land

Issues with Energy and the Environment:

- The total amount of energy used
- The efficiency of energy use
- The sources of energy

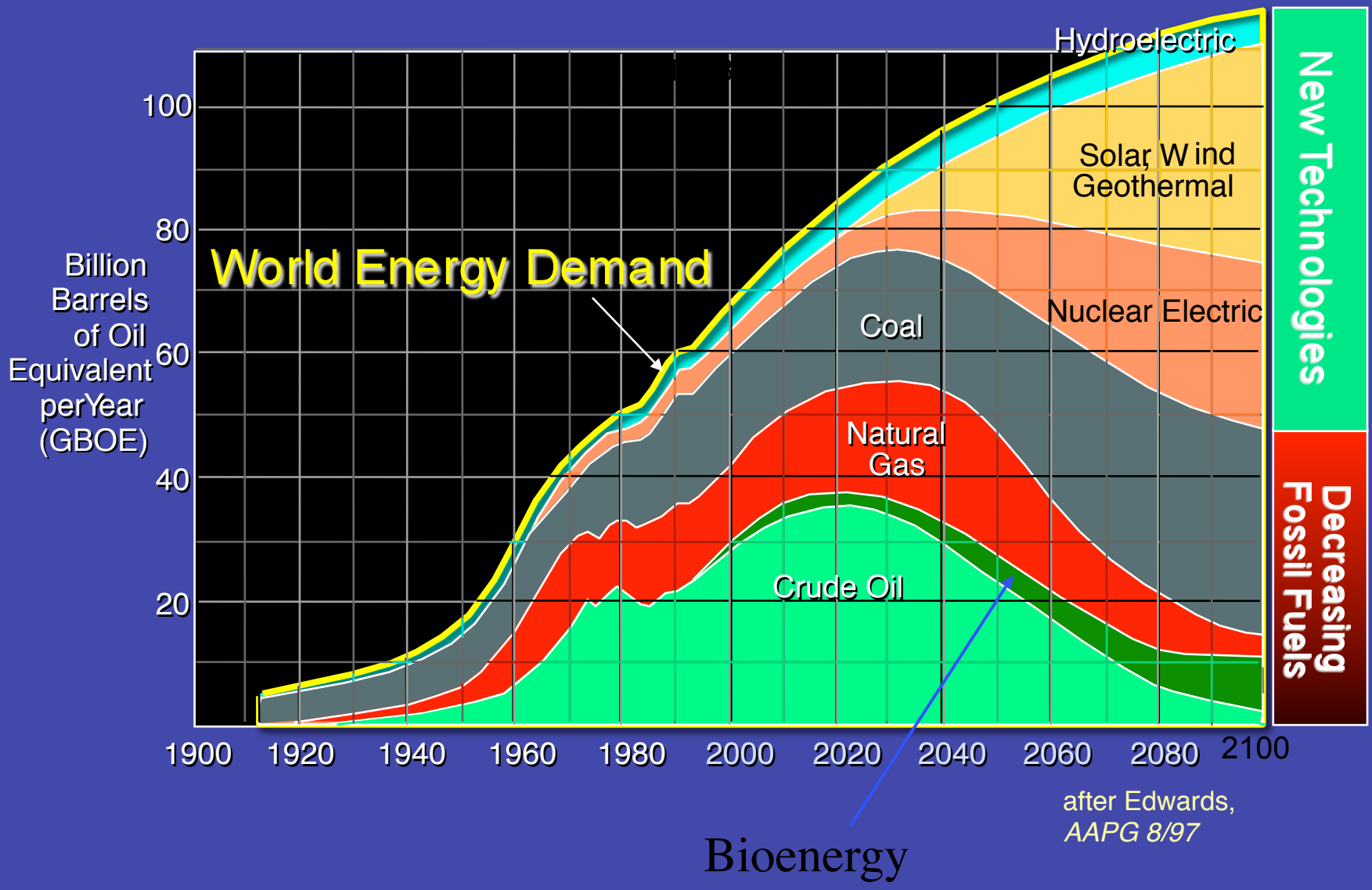
Energy Usage: 1750-2000

An Energy Dependent Society

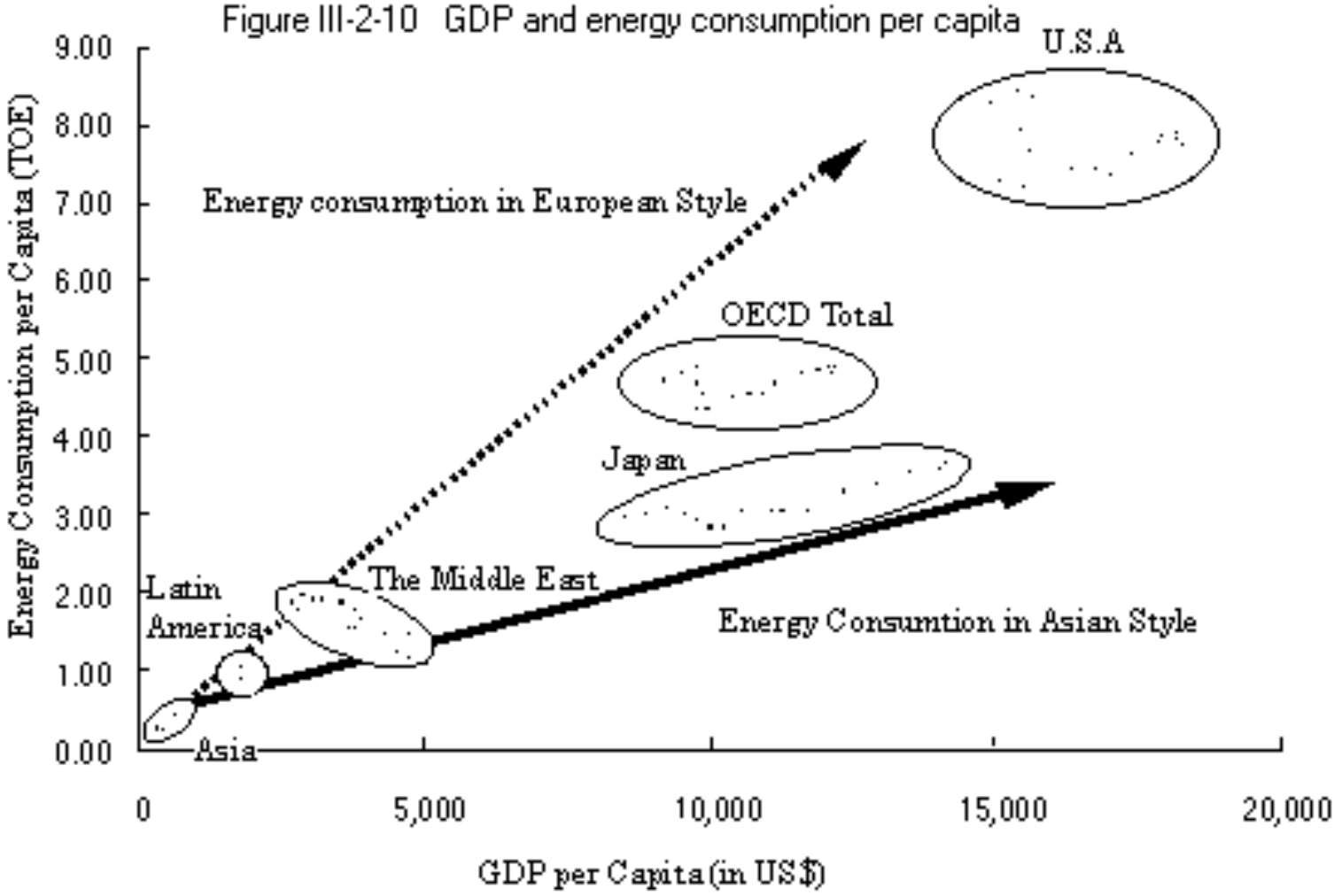


Cook and Sheath, 1997

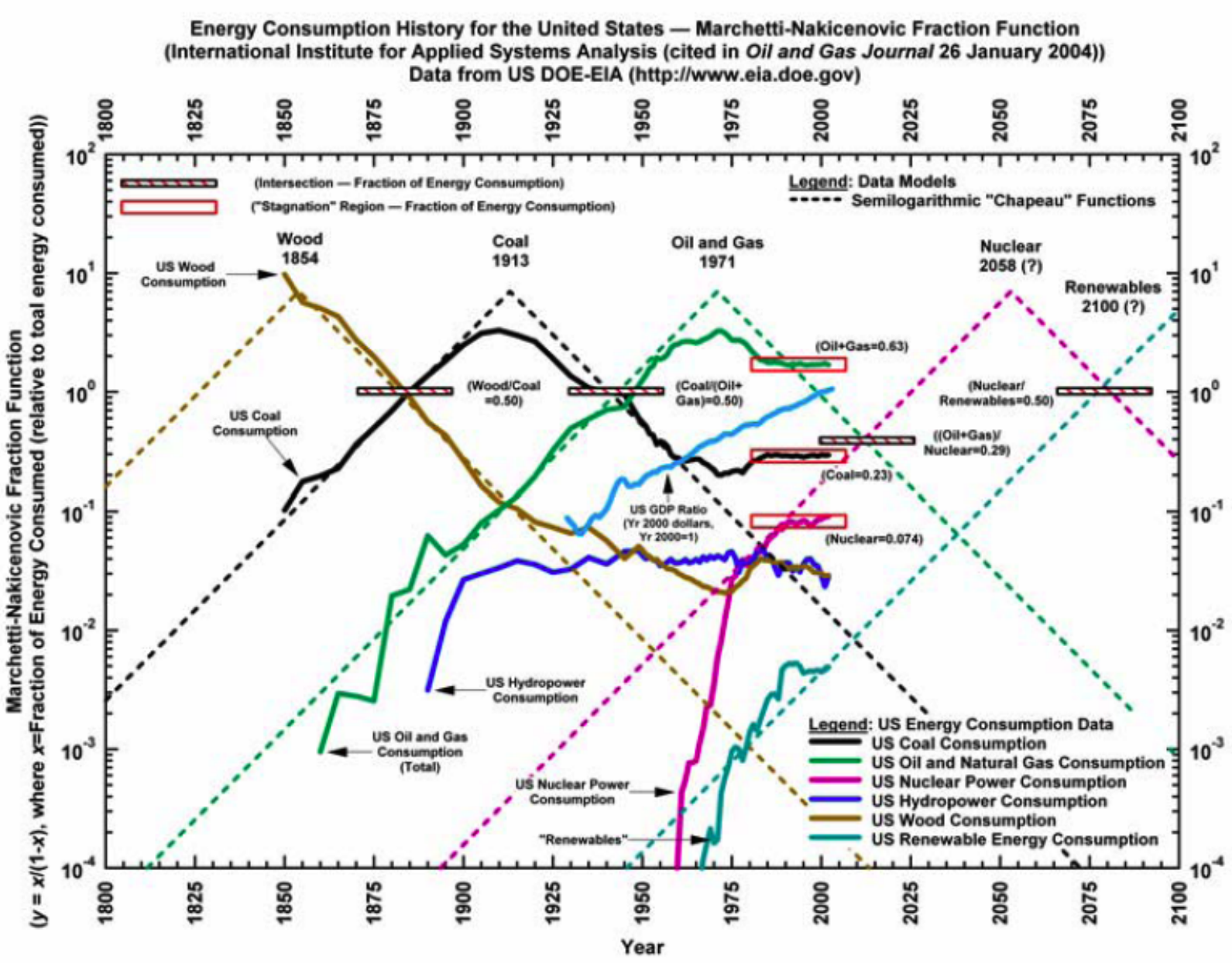
Projected World Supplies



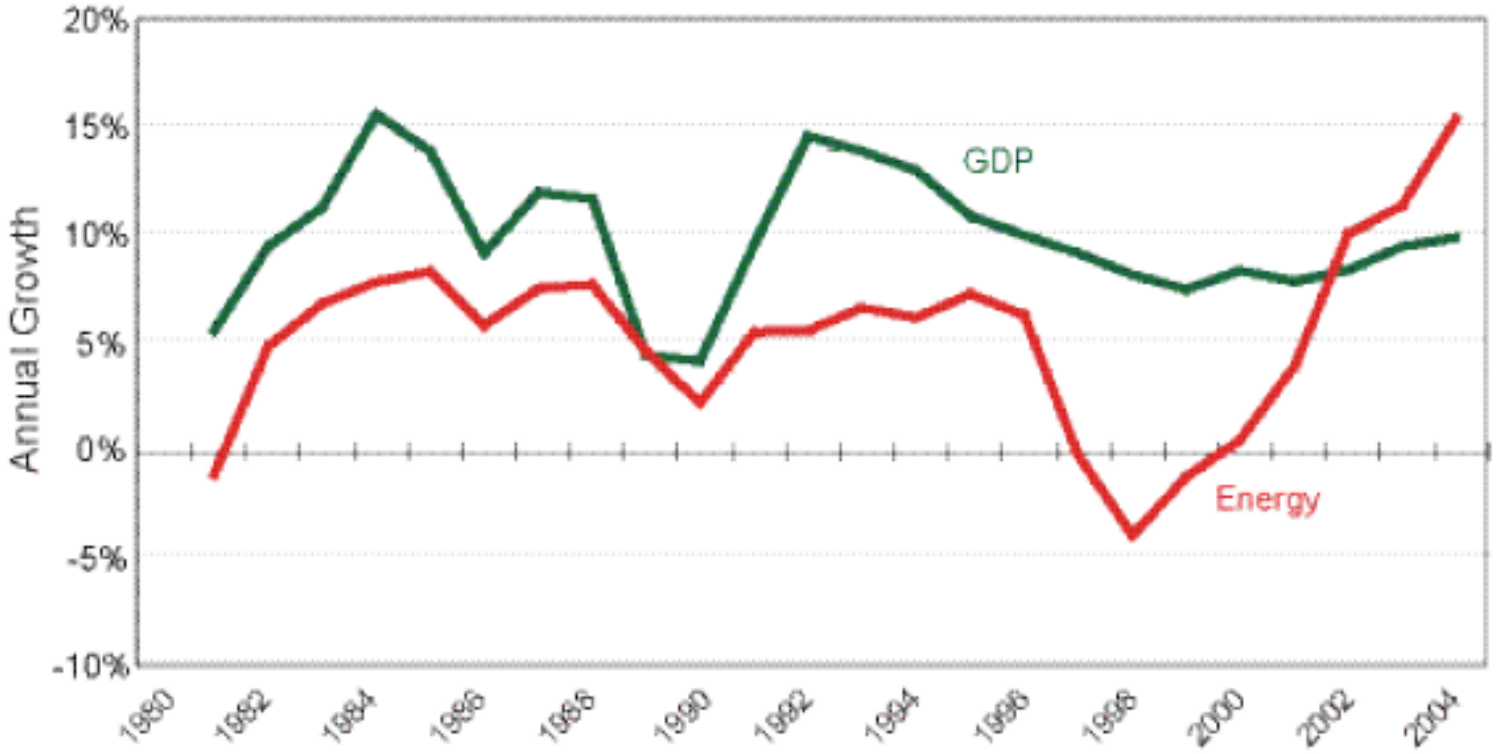
GDP and energy consumption



source:Nomura Research Institute


Energy Consumption History for the United States — Marchetti-Nakicenovic Fraction Function
(International Institute for Applied Systems Analysis (cited in Oil and Gas Journal 26 January 2004))
Data from US DOE-EIA (http://www.eia.doe.gov)
Marchetti-Nakicenovic Fraction Function
(y = x/(1-x), where x=Fraction of Energy Consumed (relative to toal energy consumed))
Year
(Intersection — Fraction of Energy Consumption)
("Stagnation" Region — Fraction of Energy Consumption)
Legend: Data Models
Semilogarithmic "Chapeau" Functions
Wood
1854
Coal
1913
Oil and Gas
1971
Nuclear
2058 (?)
Renewables
2100 (?)
US Wood Consumption
US Coal Consumption
(Wood/Coal =0.50)
(Coal/(Oil+ Gas)=0.50)
(Oil+Gas=0.63)
(Nuclear/ Renewables=0.50)
((Oil+Gas)/ Nuclear=0.29)
(Coal=0.23)
(Nuclear=0.074)
US GDP Ratio (Yr 2000 dollars, Yr 2000=1)
US Hydropower Consumption
US Oil and Gas Consumption (Total)
US Nuclear Power Consumption
"Renewables"
Legend: US Energy Consumption Data
US Coal Consumption
US Oil and Natural Gas Consumption
US Nuclear Power Consumption
US Hydropower Consumption
US Wood Consumption
US Renewable Energy Consumption

Energy and GDP in China, 1980-2004



The announced policy goal: quadruple GDP while *only* doubling energy, by 2020

Uses of Energy in China

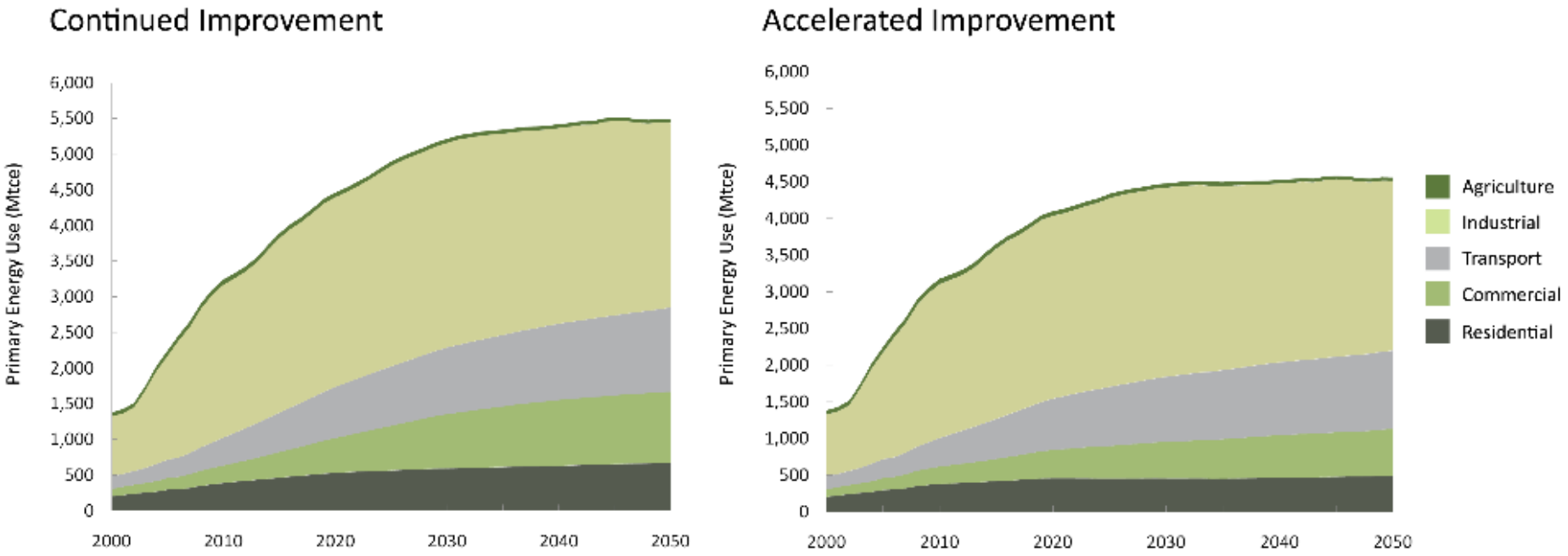


Figure 1: Primary Energy Consumption for CIS and AIS Scenarios
Source: Lawrence Berkeley National Laboratory

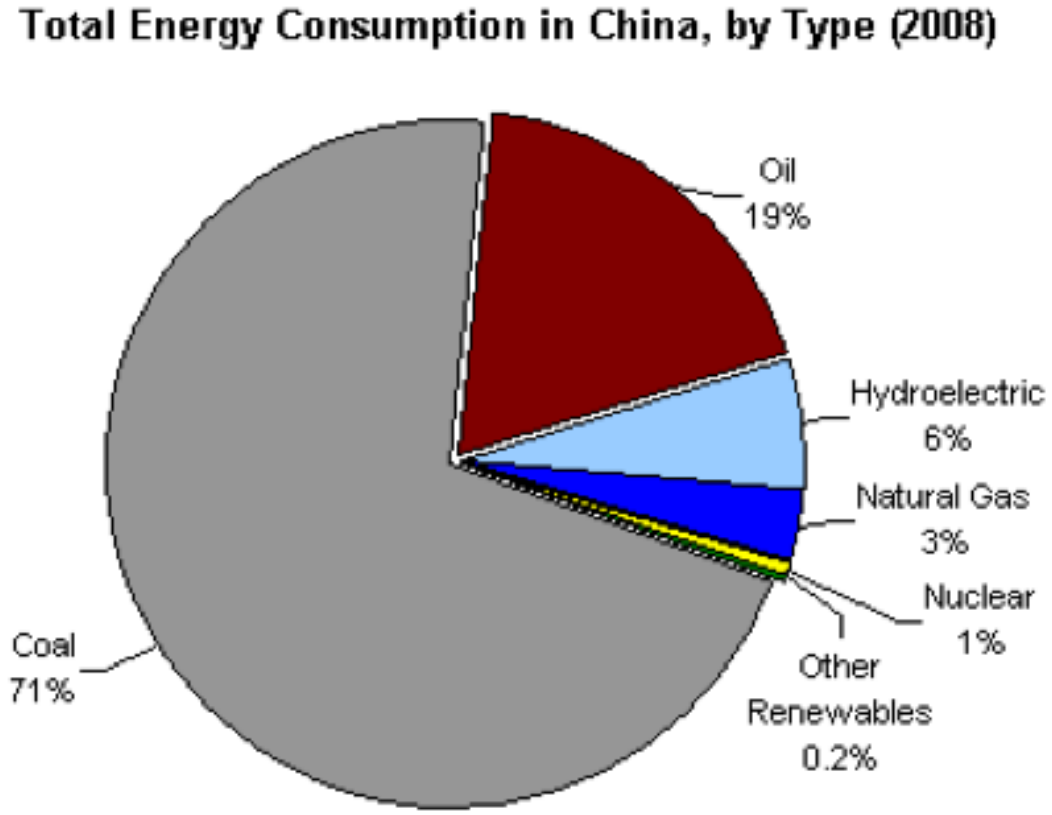
Sources of Increased Demand, 2010-2025

- Transport: More and more private cars
- Industry: Continued growth, leveling off
- Commercial: Office space, and modern skyscrapers
- Residential: Upscaling, urbanization

Sources of Decreasing Demand, Far Future

- Saturation in transport and residential
- Industry moving to high-tech
- Efficiency
- Switch to renewables
- Environmental Kuznets effects?

China Energy Sources



Source: EIA International Energy Statistics 2008

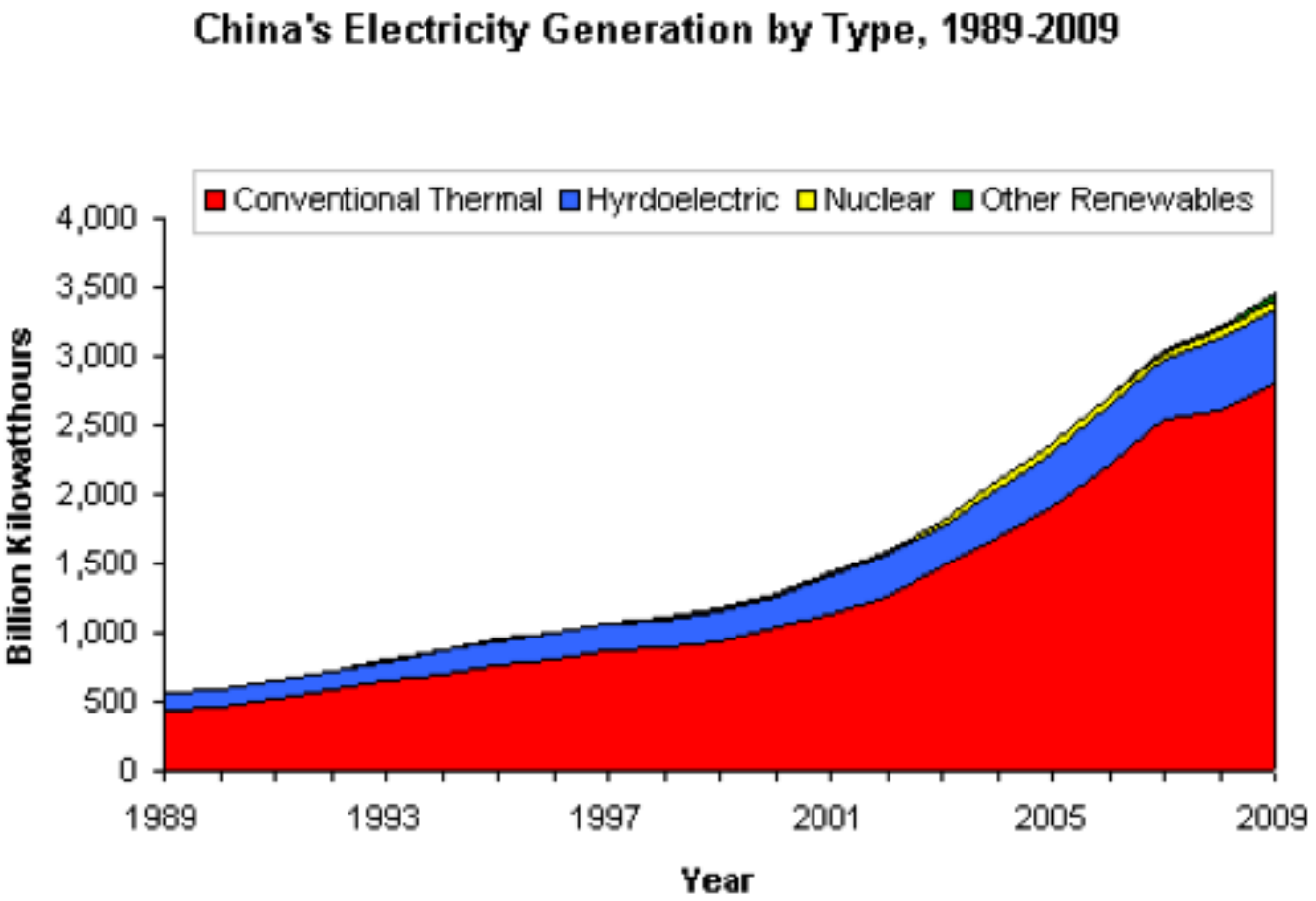
Electricity generation

Year	TOTAL	% Increase	Thermal	% Increase	Hydro	%Increase
2003	18,462.10	15.4	15,421.26	16.6	2,592.79	3.6
2004	21,302.28	14.9	17,701.71	14.4	3,065.23	17.6
2005	24,145.76	13.3	19,857.23	12.5	3,643.93	19.5
2006	27,557.46	13.7	23,188	17.1	3,783.19	3.5
2007	32,086.84	14.9	27,012.55	14.6	4,343.26	15.4
2008	34,046	5.5	27,857	3.0	5,276	17.5
2010	41400	13.9				

Electricity by Source, 2010

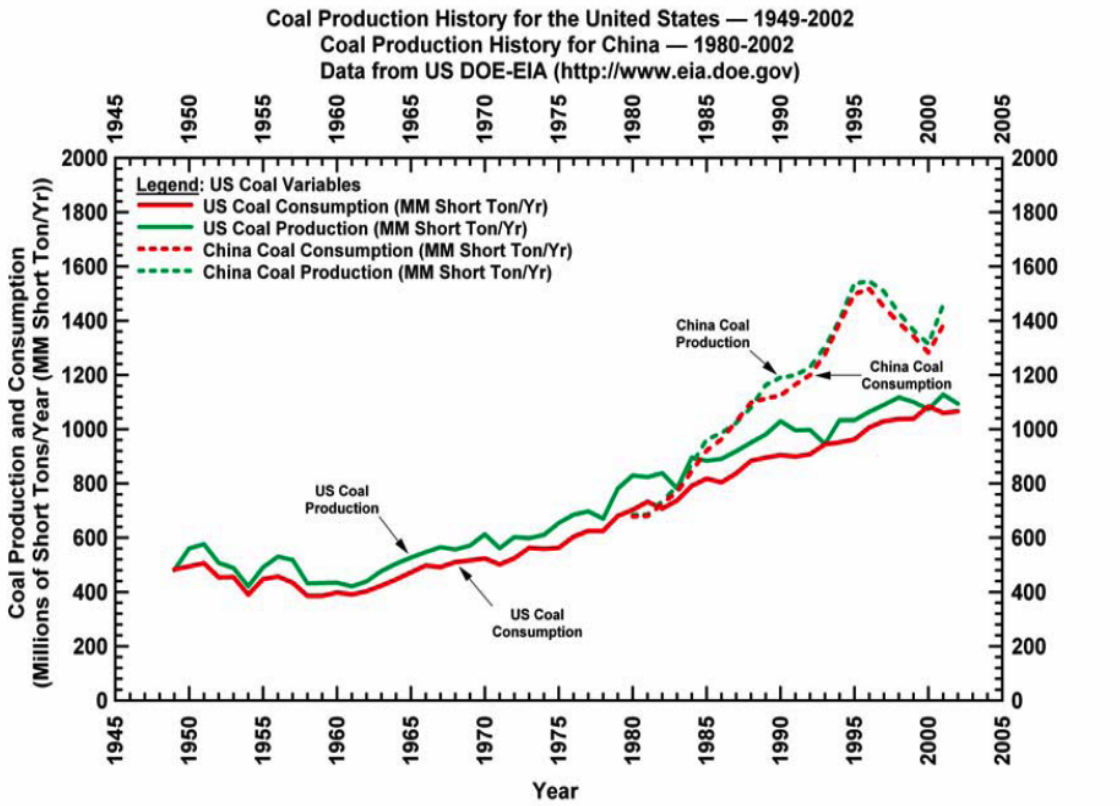
Source	Capacity
Thermoelectric (mostly coal)	700GW
Hydroelectric (mostly dams)	210 GW
Nuclear	10.8 GW
Wind	31 GW

Electricity by Type



Source: EIA International Energy Statistics

Coal: The cheapest solution



Environmental problems with coal:

- Air pollution
- Acid rain
- Highest CO_2 emissions

Coal: The cheapest solution

Country	Oil Reserves (B STB)	Oil Production (MMSTB/D)	Oil Consumption (MMSTB/D)	Net Oil Imports (MMSTB/D)	Oil Wells Drilled in 2002/total wells
China	18.3	3.39	5.26	1.87	≈ 70,000[2] (total)
United States	22.4	5.7 (8.8[1])	19.9	11.2	4964/531,010[3]

Country	Conventional Gas Reserves (tcf)	Gas Production (tcf/Yr)	Gas Consumption (tcf/Yr)	Gas Imports (tcf/Yr)	Gas Wells Drilled in 2002/total wells	Unconventional Gas Reserves (tcf)
China	53.3	1.07	1.07	–	–	1060[4]
United States	183	19.4	22.3	4.0	15947/356,767[3]	163[5]/1200[6]

Country	Coal Reserves (B sht ton)	Coal Production (B sht ton/Yr)	Coal Consumption (B sht ton/Yr)
China	126.2	1.49	1.38
United States	275.1	1.13	1.06

Country	Electric Generation Capacity (Gigawatts)	Electricity Generation (B Kilowatt-hr)	Thermal Electricity Generation (Percent)	Nuclear Electricity Generation (Percent)	Hydroelectric Electricity Generation (Percent)	"Renewable" Electricity Generation (Percent)
China	318	1420	74.5	0.6	24.9	–
United States	813	3839	74	12	12	2

The temptations of coal

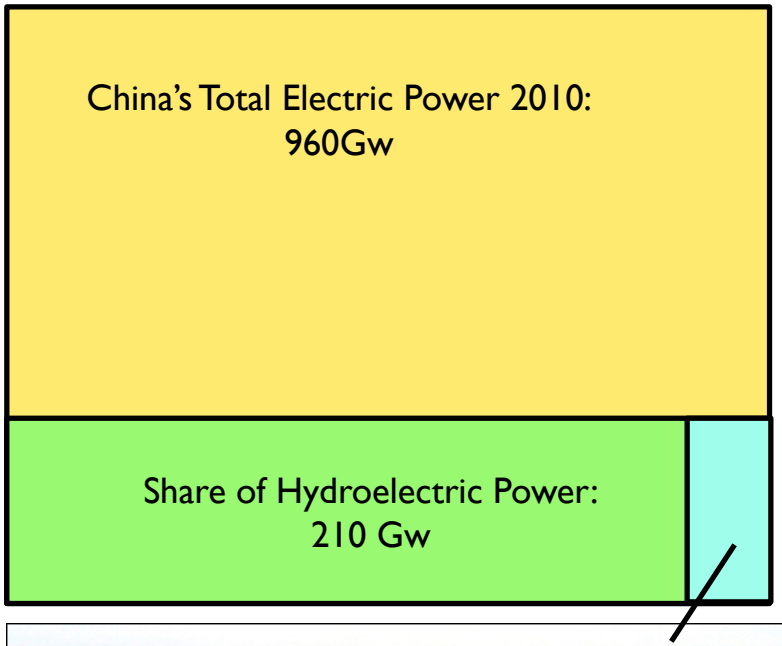
- Cheap
- Abundant
- Technology in place

China's Clean Energy Goals

Metric	*2010 Actual*	*2015 Goal*	*2020 Goal*
Non-fossil energy (% of final energy consumption)	8% (about)	**11.4%**	15%
Hydro (% of final energy consumption)		**6.5% (about)**	**>7.5%**
Hydro	210GW		300GW
Nuclear	10.8GW	**48GW**	80GW
Wind (connected)	31GW		30GW (150GW proposed)
Solar PV	700MW		1.8GW (20GW proposed)
Solar hot water		**400m m2**	300m m2 (no new target yet)

http://switchboard.nrdc.org/blogs/mdavidson/clean_energy_standard_how_chin.html

The altertnatives: Hydroelectric Power



World's Largest Hydroelectric Plants

Name of dam	Location	Rated capacity (MW) Present	Ultimate	Year Built
Itaipu	Brazil/Paraguay	12,600	14,000	1983
Guri	Venezuela	10,000	10,000	1986
Grand Coulee	Washington	6,494	6,494	1942
Sayano-Shushensk	Russia	6,400	6,400	1989
Krasnoyarsk	Russia	6,000	6,000	1968
Churchill Falls	Canada	5,428	5,428	1971
La Grande 2	Canada	5,328	5,328	1979
Bratsk	Russia	4,500	4,500	1961
Moxoto	Brazil	4,328	4,328	n.a.
Ust-Ilim	Russia	4,320	4,320	1977
Tucurui	Brazil	4,245	8,370	1984

Advantages

- Clean
- Relatively unexploited
- Renewable

Environmental Problems

- Removes agricultural land
- Destroys habitat
- Salinization in coastal regions

Oh, and what about that dam...

Why Build it?

National Pride

Hydro Power

Flood Control

Navigation

Problems:

Pollution

Endangered Species

Climate change?

Seawater incursion

Cultural Heritage

Relocation: 1.8 million

Disastrous collapse??

Oh, and what about that dam...

Why Build it?

National Pride

Hydro Power

Flood Control

Navigation

In January 2000, a senior Chinese official in Kunming expressed to me what I believe to be a deeply rooted conviction in China: “We are sensitive to considerations of the environment and the importance of the conservation of nature, but we must have power; coal is dirty, water clean and abundant,a rich and unused resource; we have no alternative.” In all other sectors of China’s economy Maoism has been displaced by market principles,but not in the hydro-sector.

Gavan McCormack, “Water Margins: competing paradigms in China, 2001

RETAINING WATER

3. THREE GORGES DAM

When it's completed in 2009, the Chinese will have built the largest dam in the world, with a reservoir you can see from the moon. The moon, Alice!

■ The finished Three Gorges Dam will be 1.2 miles wide and tower 607 feet high.

■ Crack addicts: Construction was so shoddy that the Chinese premier ordered much of the dam torn down and rebuilt. In 2002 a new series of fissures was discovered.

■ The total cost is estimated somewhere between $17 and $100 billion. (Wait—aren't Asians supposed to be excellent at math?)

■ Three Gorges will eventually generate 18,200 megawatts of energy, or the equivalent of 18 nuclear plants—plenty to keep Madonna's vibrator running for weeks.

■ The reservoir will be 370 miles long. That's farther than the annoying drive from Boston to Philadelphia . . . with a bit less traffic.

■ It'll hold 1.39 trillion cubic feet of water—150 billion more than Hoover Dam's Lake Mead, enough to flood New Jersey to a depth of 6.7 feet.

IT'S THE HUMIDITY

■ Rising water levels will erase 13 cities and 140 towns and force 1.5 million people to move. It's the largest resettlement ever undertaken for a civil engineering project, and the Chinese government hardly had to shoot any of them this time.

■ Workers are pouring a full 35 million cubic yards of cement, which would be enough to lay a 16-foot-wide highway across the U.S. . . . more than *10 times*.

■ Corruption is also rising, with 230 cases of embezzlement and $57 million vanishing, leading to a death sentence for one official.

■ The builders are taking out 133 million cubic yards of earth and dumping 38 million cubic yards of stone back in. They're erecting 309,662 tons of metal structures (enough for 280 billion paper clips), using 390,108 tons of reinforcing bars (which could make 1.29 billion Slinkys—we can do this all day, people) and 2.5 million square feet of leakproof concrete walls.

CHINESE DELIVERY! SOMEDAY . . .

It took hundreds of years to build the other wall in China. This one will take less than 20. Now that's progress!

STAGE ONE (1993 TO 1997)
A cofferdam was built: Giant 77-ton trucks dumped rocks into the water until they cut off a portion of the river. Entire factories were built on-site to supply equipment. The water was drained, workers dug the dry riverbed deeper to divert the river through it, and the dam was then reinforced with concrete.

STAGE TWO (PROJECTED TO FINISH 2003)
They started building the main dam from the other side, using the same dam approach of first building a temporary cofferdam. A giant dam power plant is currently being built alongside the dam, along with a pair of dam shiplocks to move supply vessels around the dam during construction.

STAGE THREE (2004 TO 2009)
The remaining channel of the river will be walled off with yet another cofferdam, the real dam will be extended all the way across, then some politician will cut a ribbon, and voilà! Insta-lake. Now everyone can finally crack open their fortune cookies on the skulls of any remaining political dissenters.

■ The dam will manage flooding on the Yangtze River, which has killed over 300,000 people in the past century, while supplying electricity for an underdeveloped region.

■ Ships will be able to travel 7,500 miles inland, opening up a market of 380 million people. (Egg roll in 30 minute or money back!)

■ But where did they put all those people? The Chinese claim that the thousands who have moved "enjoy a better life, thanks to the assistance of the government." OK, then!

■ On the other hand, human rights groups claim that Chinese police are relocating people by force. One Chinese government official admitted that if they can't move everyone, they'll just "have to use floodwater to force the people out."

■ One slight environmental problem: Flooding all those towns and factories will release untold amounts of toxic waste that's now buried on dry land. In addition, experts have estimated another one billion tons of industrial and human waste will be dumped into the reservoir each year. Everybody in the pool!

■ An estimated 123 different sources of radioactive debris will also be flooded. Um, waiter? Cancel that poached dog.

BLUNDER CONSTRUCTION

Saluting America's most memorable crumbling pieces of crap.

TACOMA NARROWS BRIDGE
Nicknamed "Galloping Gertie" for its tendency to twist in the wind, the bridge became the freak show of Tacoma, drawing herds of people to witness her gyrations and ride her. Engineers had chosen not to reinforce the span against high winds, and on November 7, 1940 a mere 42 mph breeze caused ol' Gert to rock so violently that cement waves as high as 28 feet rippled across the span, which snapped and collapsed into Puget Sound. (Luckily, three people got off just before it fell.)

U.S. INDUSTRIAL ALCOHOL COMPANY MOLASSES TANK
On January 15, 1919, a storage tank holding 2.5 million gallons of molasses exploded, creating a 15-foot tidal wave of sweetness that rushed at 35 mph through downtown Boston, leaving everything brown and sticky like a Mexican restaurant men's room. Apparently, the tank wasn't built to withstand fermentation, which had occurred as the temperature rose 40 degrees in three days. The Great Molasses Flood knocked down several buildings and an elevated train line and drowned 21 unfortunate (and evidently slow) people.

HYATT REGENCY SKYWALKS
A dance contest at a Kansas City hotel on July 17, 1981 ended with a thud when two skywalks collapsed, leaving 114 people dead and 200 more injured. The cause? The architects had demanded that the skywalks look "thin and airy," so they, like you, were equipped with an undersize rod and nut. Engineers attached rods from the lower to the upper skywalk (instead of to the ceiling), expecting one nut to support the weight of both. It didn't.—*Laura Leu*

Honestly? Maxim Magazine?

Hydro Power

China's Total Electric Power Needs 2010:
450Gw

Desired share of Hydroelectric Power:
150 Gw

Sanxia:
18 Gw

World's Largest Hydroelectric Plants

Name of dam	Location	Rated capacity (MW) Present	Ultimate	Year Built
Itaipu	Brazil/Paraguay	12,600	14,000	1983
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Relocation Problems

Quality of the land available

New ecotechnical adaptation

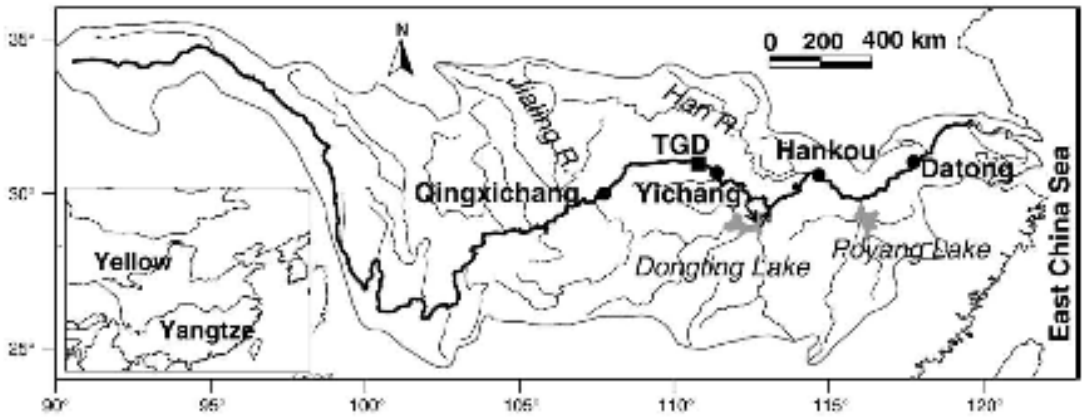
Lack of education for urban life

Dialect differences

Insufficient funds

Corruption and official indifference

Sedimentation changes since 2003



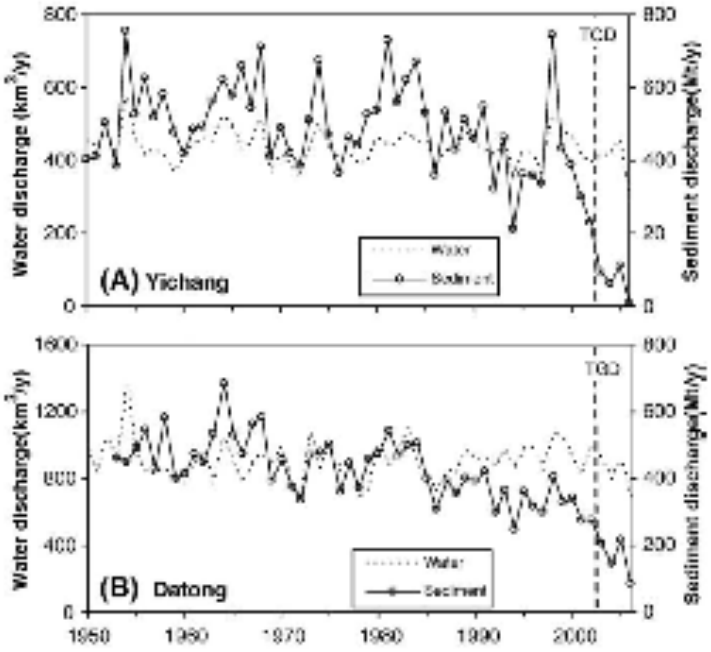


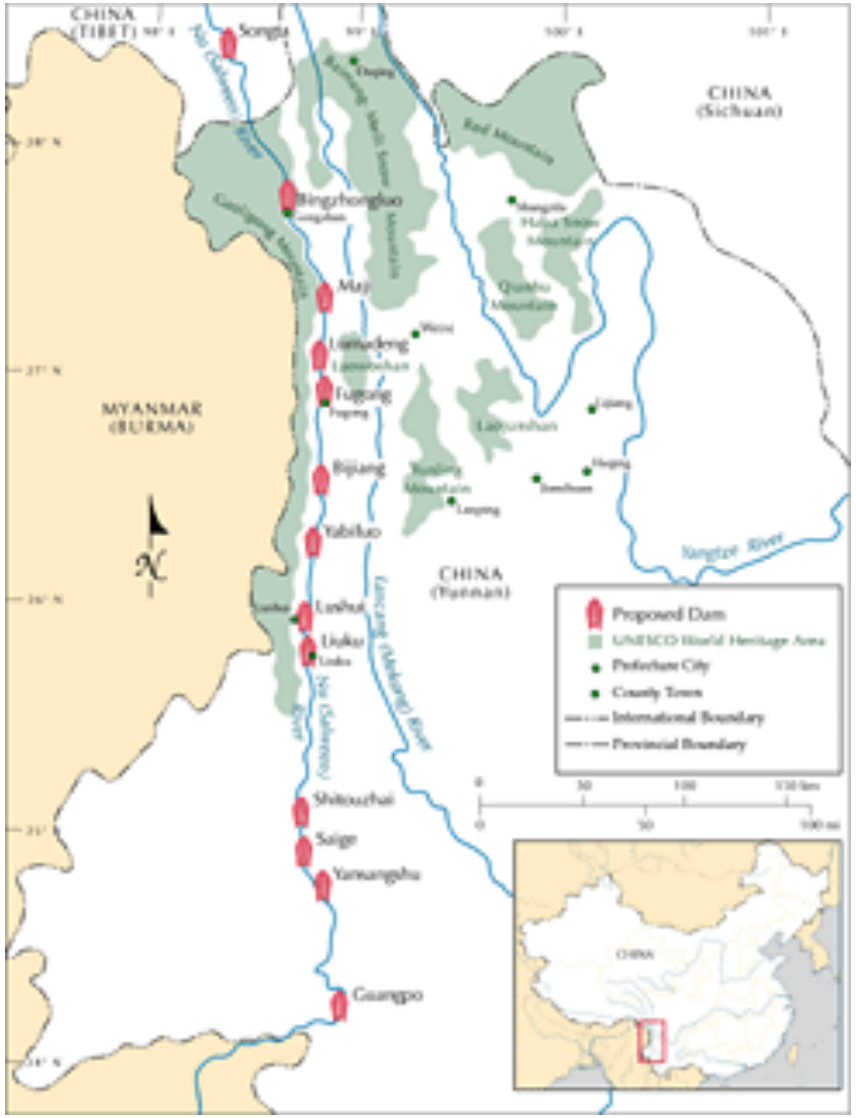
Table 1
Sediment budget in the middle-lower reaches of the Yangtze River (unit: Mt/y)

Year	Yichang	Dongting Lake	Han River	Hankou	Poyang Lake	Datong	Channel deposition(+)/erosion(−)		
							Yichang to Hankou (630 km)	Hankou to Datong (510 km)	Yichang to Datong (1140 km)
1950–2000	501	−86	56	404	30	433	**67**	**−19**	**48**
2001	299	−23	3	285	12	276	**−6**	**21**	**15**
2002	228	−16	3	239	14	275	**−24**	**−22**	**−46**
2003	98	−3	14	165	18	206	**−56**	**−23**	**−79**
2004	64	0	5	136	14	147	**−67**	**3**	**−64**
2005	110	−8	17	174	16	216	**−55**	**−26**	**−81**
2006	9	14	3	58	14	85	**−32**	**−13**	**−45**

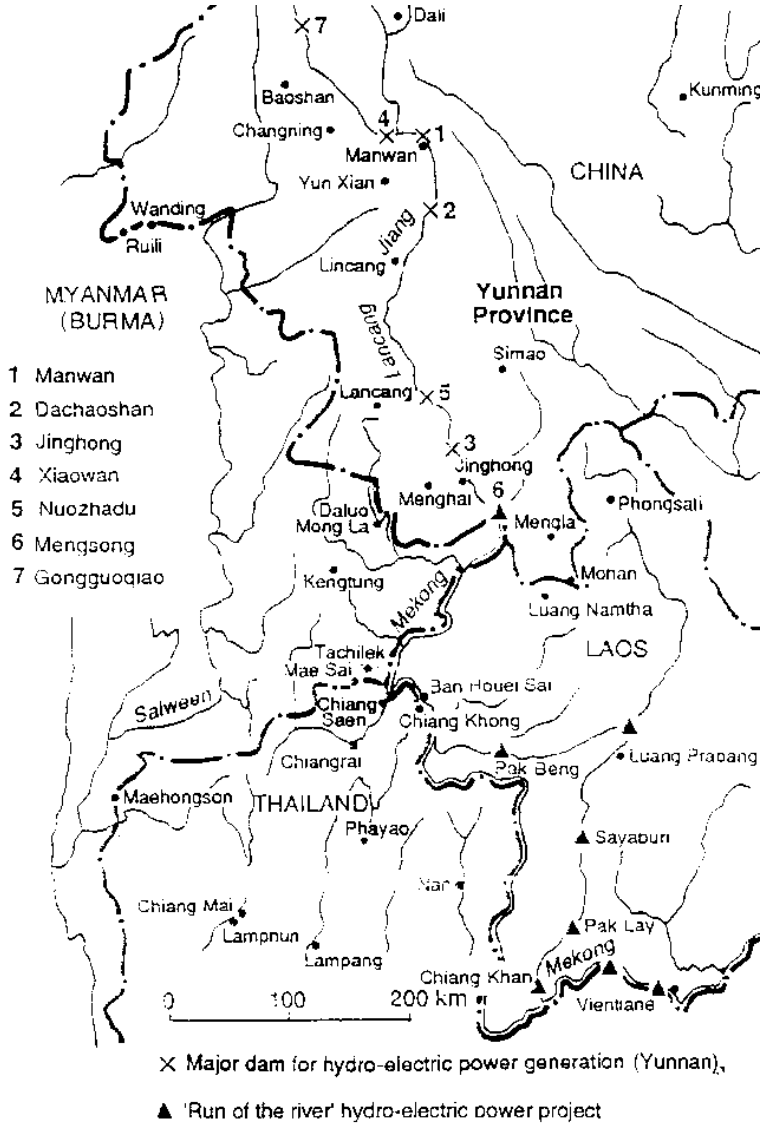
Sedimentation changes since 2003

- More is building up behind the dam (max depth 56m)
- Downstream reaches have changed from deposition to erosion
- The Yangtze delta has gone from expansion to contraction

There are still more dams….



Nu (Salween) River



Lancang (Mekhong) River

There are still more dams….

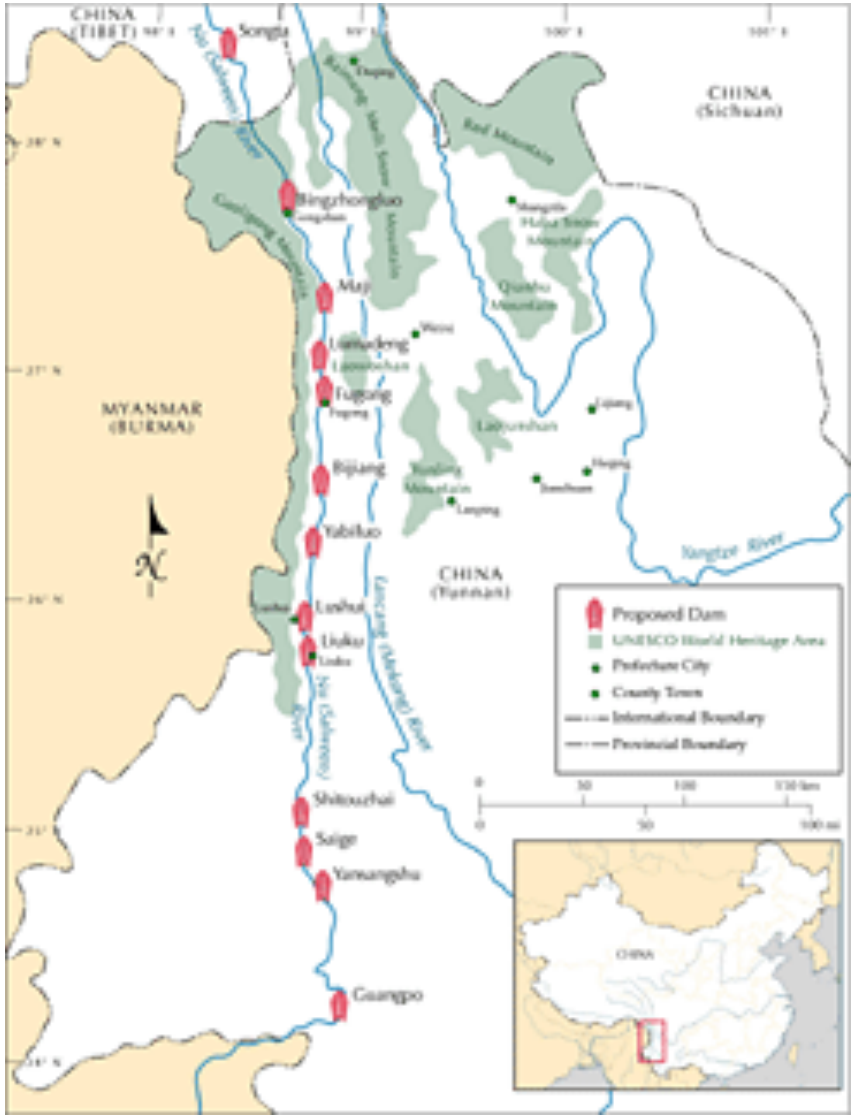
Table 2. LANCANG RIVER CASCADE

	Gong-guoqiao	Xiao-wan	Man-wan	Dachao-shan	Nuo-zhadu	Jing-hong	Gan-lanba	Meng-song
Elevation[1]	1,319	1,240	994	899	812	602	533	519
Reservoir volume[2]	5.10	151.32	10.60	8.84	223.68	12.33	n.a.	n.a.
Installed power[3]	710	4,200	1,500	1,350	5,500	1,500	150	600
Annual output[4]	40.60	188.90	78.05	67.00	237.77	80.59	7.80	33.80
Wall[5]	n.a.	292	126	110	n.a.	118	n.a.	n.a.
Status[6]	design	2002-2012	1986-1996	1996-2003	pre f.s.	2006-2013	design	design

Sanxia: 1500

Note: The dams listed (left to right) run from north to south. 1. Elevation is level of the dam's reservoir in meters above sea level. 2. Volume is reservoir holding capacity in hundred million cubic meters. 3. Installed power is installed power capacity in megawatts. 4. Annual output is annual electrical power output in hundred million kilowatt hours. 5. Wall is the height in meters of the main dam wall. 6. Status indicators are: already built; under construction (with years); feasibility stage (f.s.); pre-feasibility stage (pre f.s.); or design stage. *Table source:* Hayao Adachi 's website:

There are still more dams….



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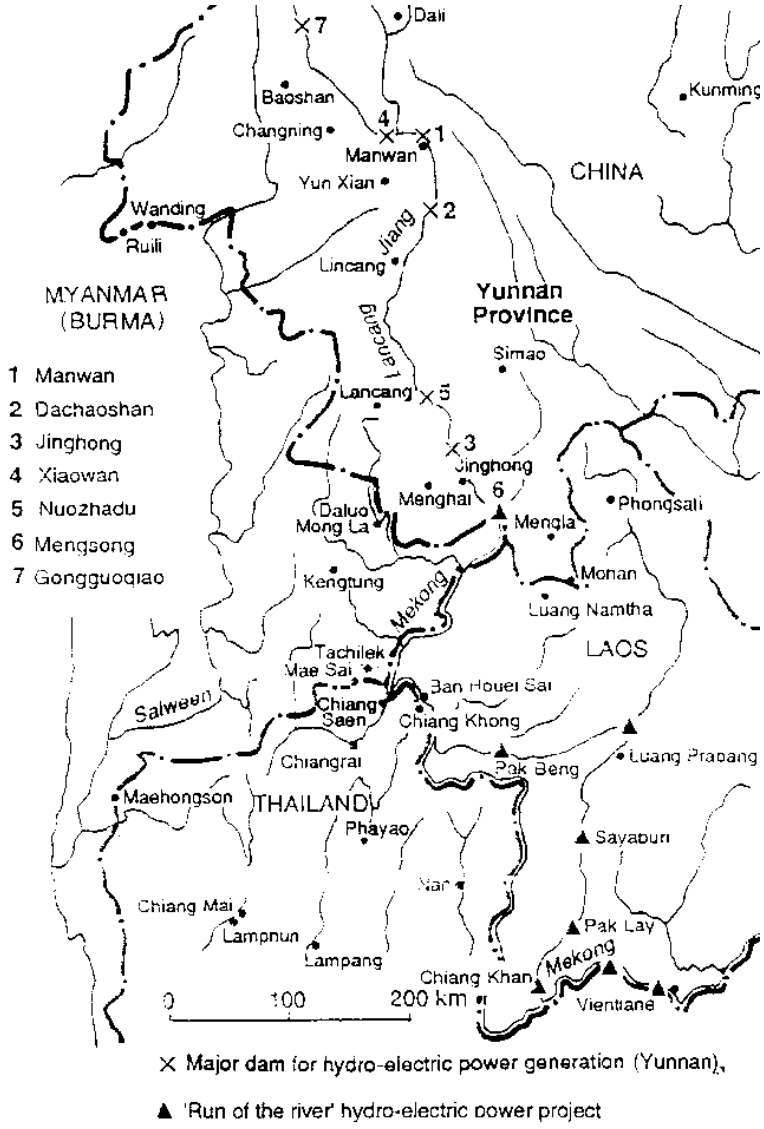

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Wall[5]	n.a.	292	126	110	n.a.	118	n.a.	n.a.
Status[6]	design	2002-2012	1986-1996	1996-2003	pre f.s.	2006-2013	design	design

Note: The dams listed (left to right) run from north to south. 1. Elevation is level of the dam's reservoir in meters above sea level. 2. Volume is reservoir holding capacity in hundred million cubic meters. 3. Installed power is installed power capacity in megawatts. 4. Annual output is annual electrical power output in hundred million kilowatt hours. 5. Wall is the height in meters of the main dam wall. 6. Status indicators are: already built; under construction (with years); feasibility stage (f.s.); pre-feasibility stage (pre f.s.); or design stage. *Table source:* Hayao Adachi 's website:

You be the judge, again:

Problems Caused by Energy Shortages in China

- Lack of electricity in rural areas
- Frequent blackouts
- Increased reliance on coal
- Possible belligerence over oil

Vs.

What are the Environmental Costs of More Dams?

- Deprivation of Downstream peoples
- Loss of Biodiversity
- Loss of Scenic Beauty
- All the problems of relocation
- Possible disasters

Carbon Emissions

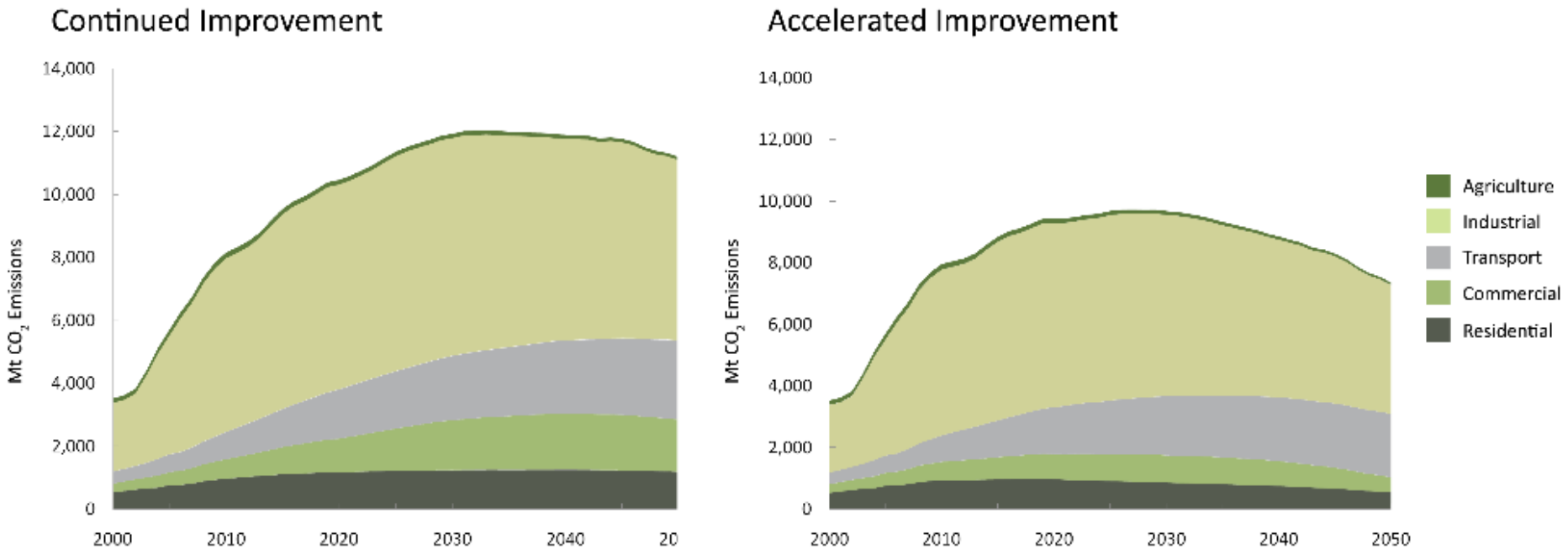

Figure 2: Carbon Emissions Outlook for CIS and AIS Scenarios
Source: Lawrence Berkeley National Laboratory

Lack of Energy Solutions

Energy Sources

- Oil
  - Short supply
  - Greenhouse gas
  - Air Pollution
  - No good alternative for transportation
- Coal
  - Greenhouse gas
  - Air pollution
- Hydroelectric
  - Supply limited
  - Agriculture land and habitat loss
- Nuclear
  - Dangerous
  - No domestic fuel source

- Energy efficiency
  - Gains to be made
  - Requires incentives
  - Requires institution building
  - In the absence of technological breakthrough, will not be enough

What Needs to be Done?

- Develop long-term sustainable energy strategy, including incentives for clean and renewable sources
- Increase funding for environmental regulation
- Develop price structure for resources that will promote conservation
- Make environmental protection a primary element of cadre evaluations
- Allow citizen groups to form and lobby for environmental reform