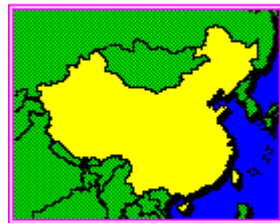
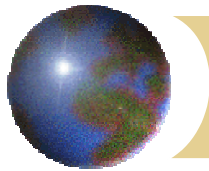


CHINA ENERGY FUTURE: LEAP TOOL APPLICATION IN CHINA

Baolei GUO, Yanjia WANG, Aling ZHANG

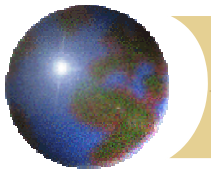
Tsinghua University





GENERAL INTRODUCTION

- Funded by Nautilus Institute, LEAP modeling in China started from 2001.
- This project has two stages: assembling dataset for LEAP and scenario analysis.
- This presentation is based on the paper prepared by Mr. Guo.
- Prof. Yanjia Wang, Prof. Aling Zhang, and Dr. David Von Hippel have been of great help to the complete of the paper's Chinese version.

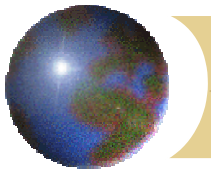


DEVELOPING FUTURE SCENARIOS FOR CHINA

⊕ Step I: Define a focal issue

China Energy Future Scenario Focal Issue

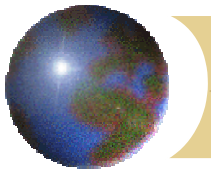
How will diversified and clean energy supply be realized in the next 30 years?
Will new priorities emerge from regional cooperation? What impact will these new factors have on China's energy pathway?



DEVELOPING FUTURE SCENARIOS FOR CHINA

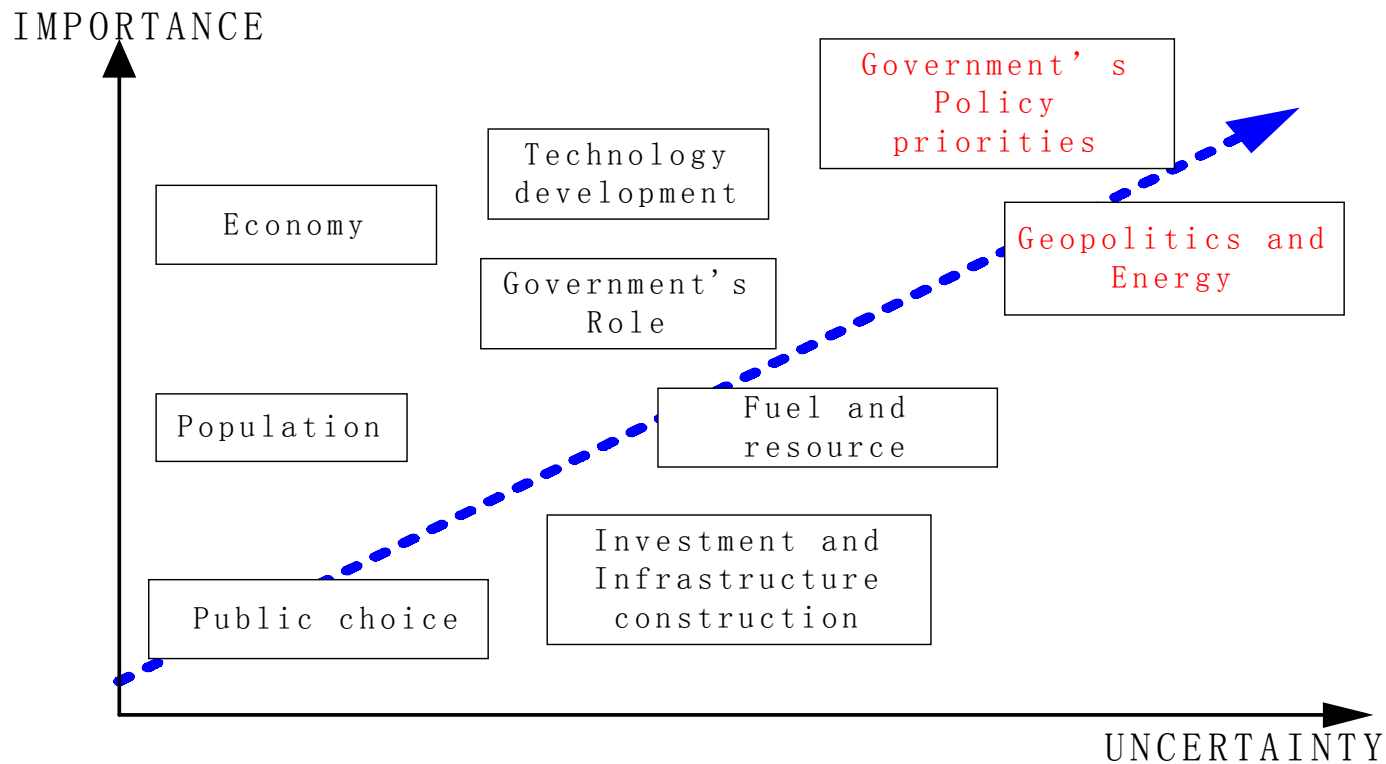
❊ Step II: List important forces in the environment

- 1 regional economic cooperation,
- 2 political relationship,
- 3 social development (including population increase, education, government deregulation, etc.),
- 4 technological progress.
- 5 the energy demand and supply situation,
- 6 the possibility of regional cooperation,

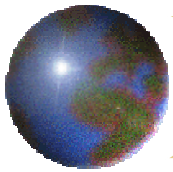


DEVELOPING FUTURE SCENARIOS FOR CHINA

Step III: Evaluate forces by importance and uncertainty

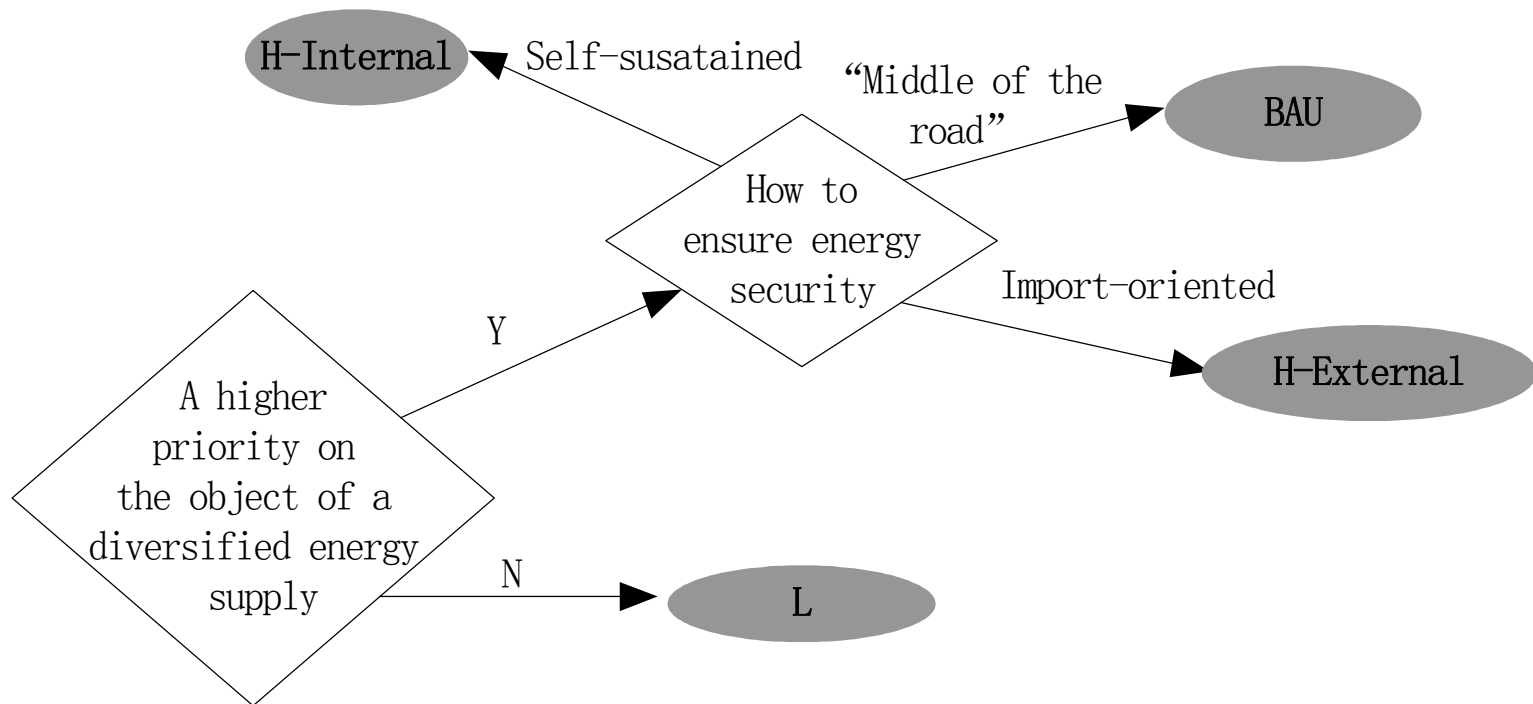


Identifying key driving forces

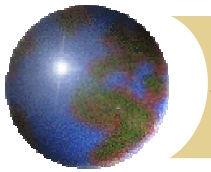


DEVELOPING FUTURE SCENARIOS FOR CHINA

Step IV: Select scenario logic



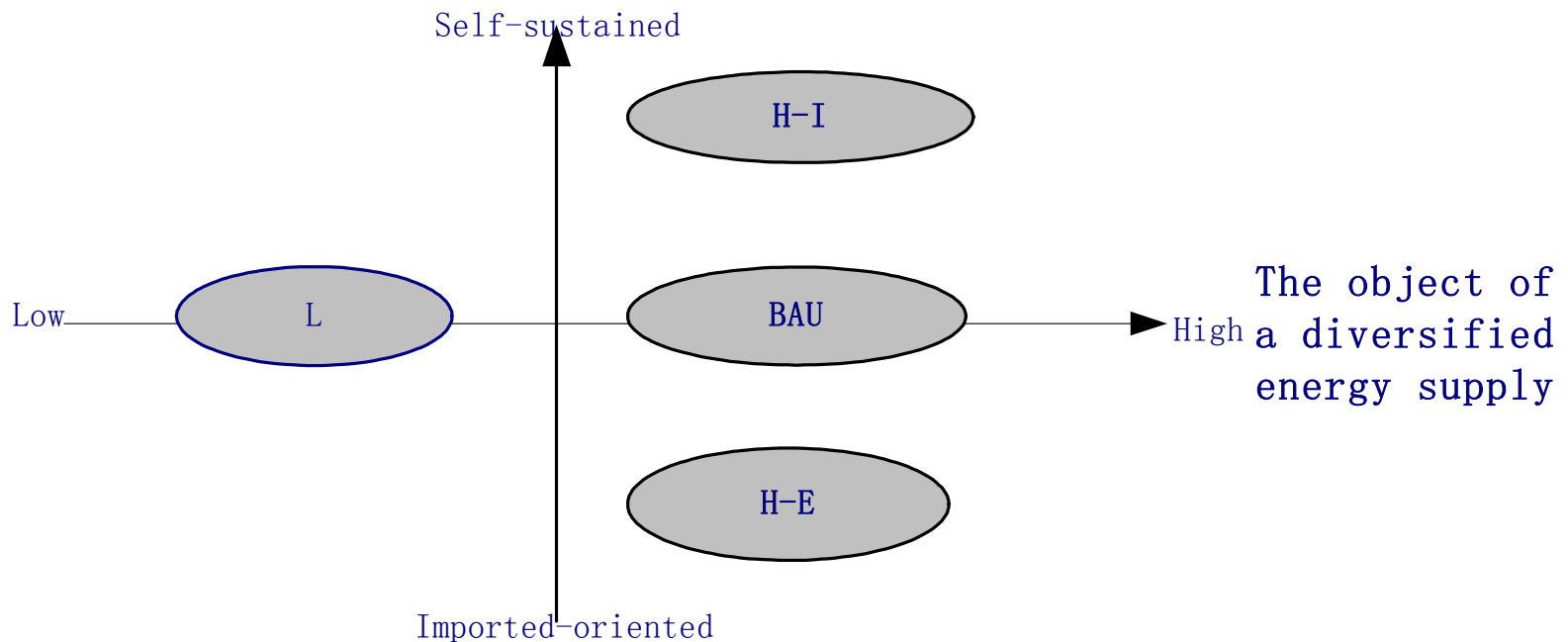
Select scenario logic

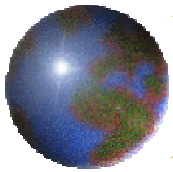


DEVELOPING FUTURE SCENARIOS FOR CHINA

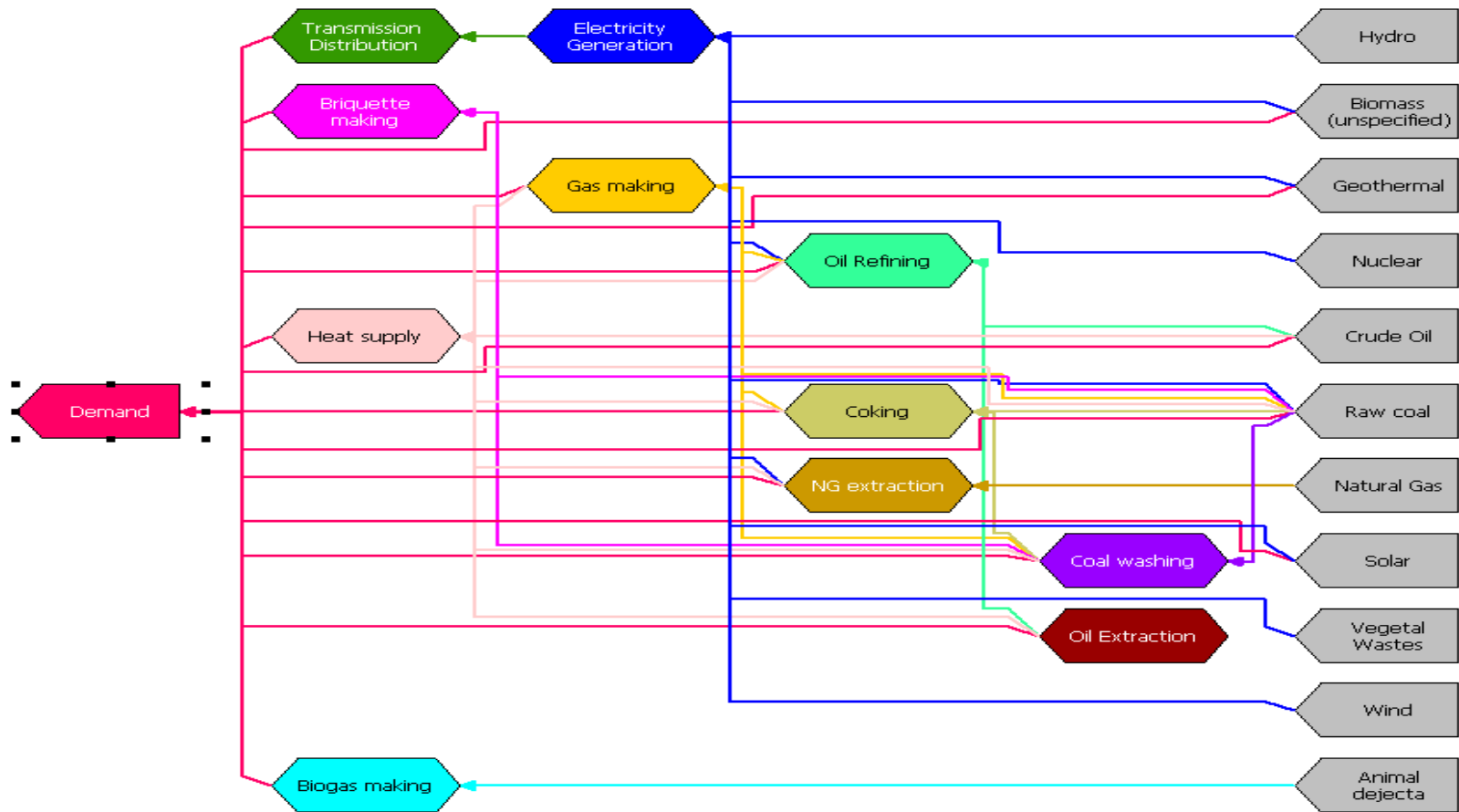
Step V: Develop scenarios around critical uncertainties

How to ensure energy security?

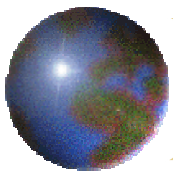




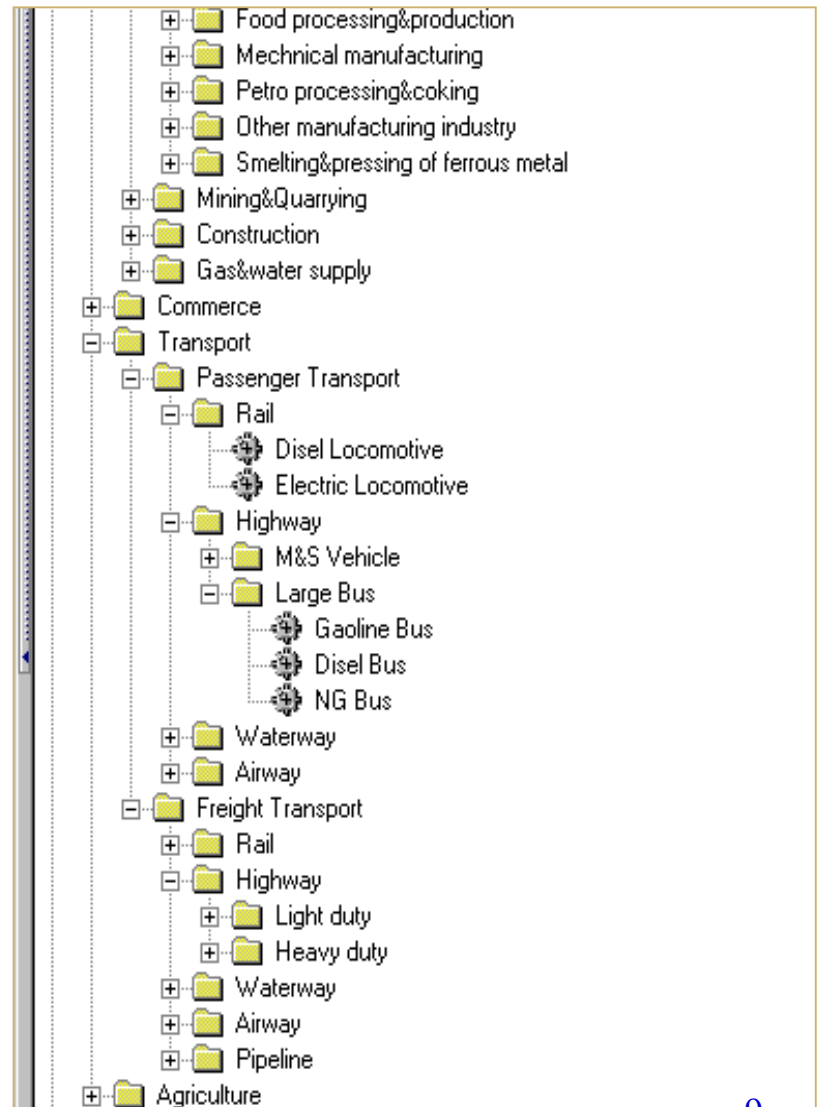
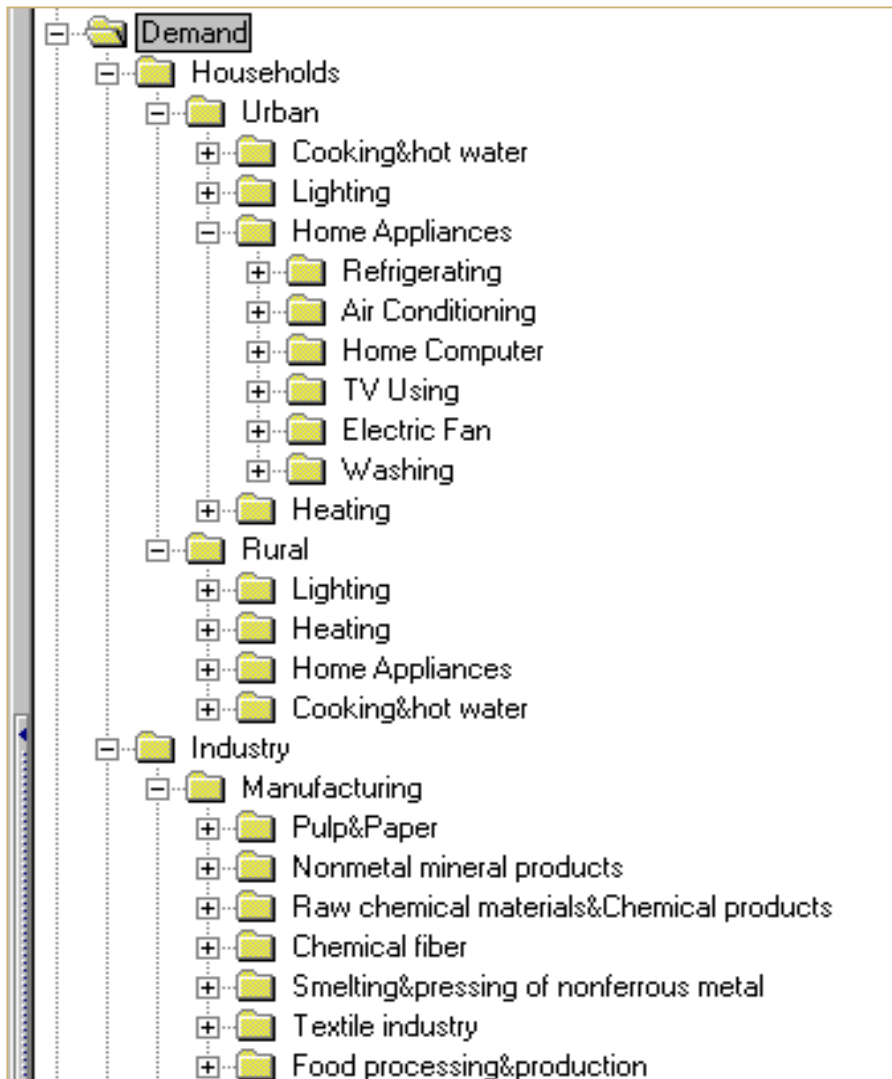
Modeling the structure



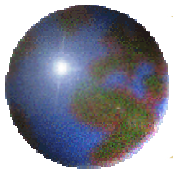
LEAP-China Model Structure



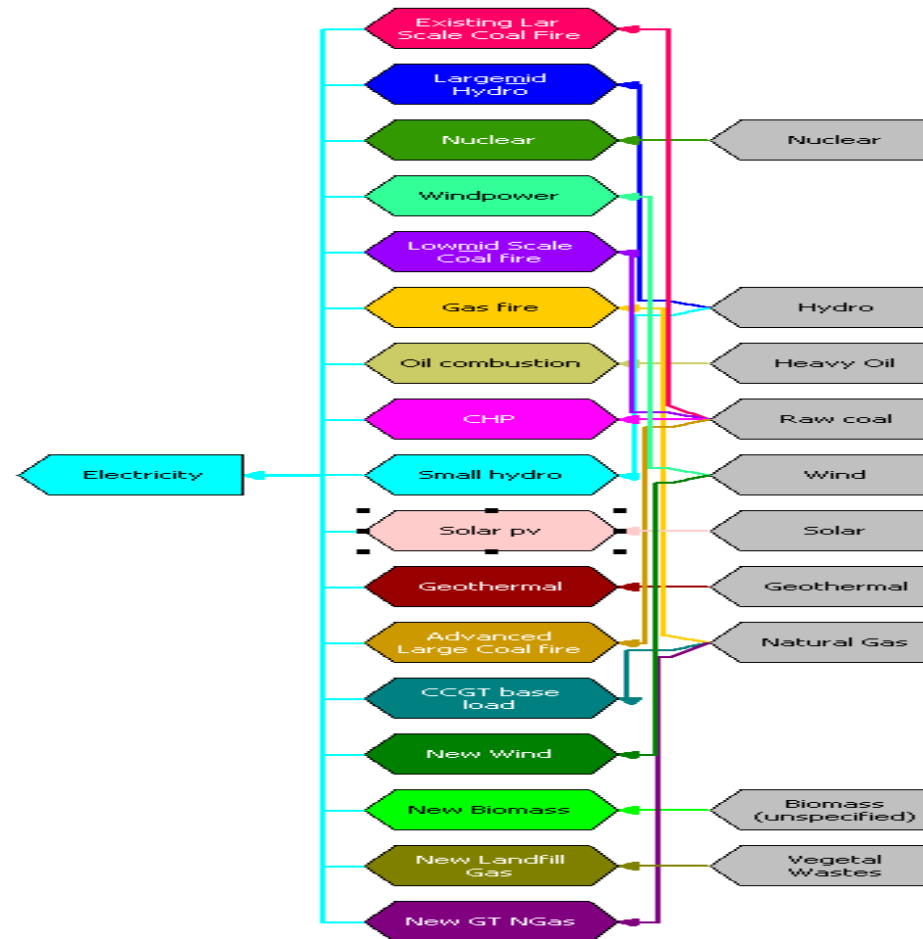
Modeling the structure



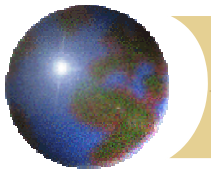
Tree structure of demand sector



Modeling the structure

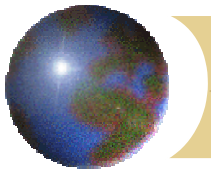


Tree structure of Power Generation sector



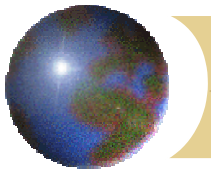
Assumptions of Business-As-Usual Scenario

- ✦ **The BAU scenario is based on a set of assumptions derived either directly or through interpretation of official state-level forecasts and plans.**



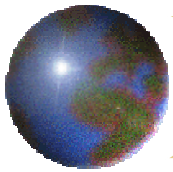
Assumption of Alternative Scenarios

- ❖ **H-E scenario: more natural gas is widely used in almost all demand sectors and electricity generation while the use of coal is further decreased. As to renewable energy and nuclear power utilization, no further efforts are made to promote their use.**



Assumption of Alternative Scenarios

- ❖ **H-I scenario: the program of renewable energy utilization makes the biomass still act as an important fuel type in residential sector. Nuclear power is widely used in electricity generation. More new energy techniques are used in power generation. Coal still plays an important part in almost all demand sectors.**



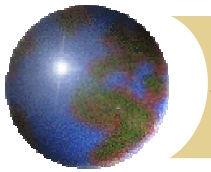
MODELING RESULTS

- Overview of Final energy demand spanning 1999-2030 in Business-as-usual and other alternative scenarios

China: Final energy demand in final energy units: demand
Units: million tonne of coal equivalent

	Base year	Fuel Mix	BAU2030	Fuel Mix	HE 2030	Fuel Mix	HI 2030	Fuel Mix
Biomass	204.4	16.4%	121.3	5.0%	119.3	5.0%	167.4	6.7%
Coal	534.2	42.9%	926.3	38.2%	830.1	35.0%	879.1	35.3%
Electricity	138.5	11.1%	329.3	13.6%	339.4	14.3%	339.4	13.6%
Heat	42.8	3.4%	108.3	4.5%	108.3	4.6%	108.3	4.3%
NG	23.9	1.9%	76.5	3.2%	248	10.5%	86.5	3.5%
Oil products	283.1	22.7%	800.6	33.0%	674.6	28.4%	801.1	32.1%
Other fuels	11.9	1.0%	19.2	0.8%	8.6	0.4%	17.4	0.7%
Renewables	1	0.1%	36.4	1.5%	36.4	1.5%	86.6	3.5%

final energy demands and fuel mix of each scenario



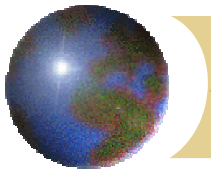
MODELING RESULTS

Overview of Business-as-usual scenario: final energy demand and sector energy demand

China: Net final energy demand in final energy units: demand
 Scenario: Business-as-usual
 Units: million tonne of coal equivalent

	1999	2005	2010	2015	2020	2025	2030	Avg Growth Rate
Renewables	1	7.2	12.8	18.8	24.9	30.9	36.4	12.3%
Other fuels	11.9	11.3	12.5	13.9	15.6	17.3	19.2	1.6%
Oil Products	283.1	353.8	424.3	506.3	600.8	695.5	800.6	3.4%
Natural Gas	23.9	30.5	37.5	45.4	54.5	64.9	76.5	3.8%
Heat	42.8	51.5	61.1	71.3	82.9	95	108.3	3.0%
Electricity	138.5	164.7	192.5	222.8	256.2	291.7	329.3	2.8%
Coal, Coke and Peat	534.2	587	654.2	722.3	791.4	859.1	926.3	1.8%
Biomass	204.4	194.2	183.3	171.7	157	140.1	121.3	-1.7%

final energy demand of BAU scenario



MODELING RESULTS

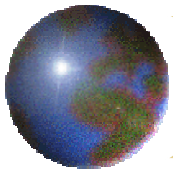
China: Net final energy demand in final energy units: demand

Scenario: BAU Reference, Fuel: All Fuels

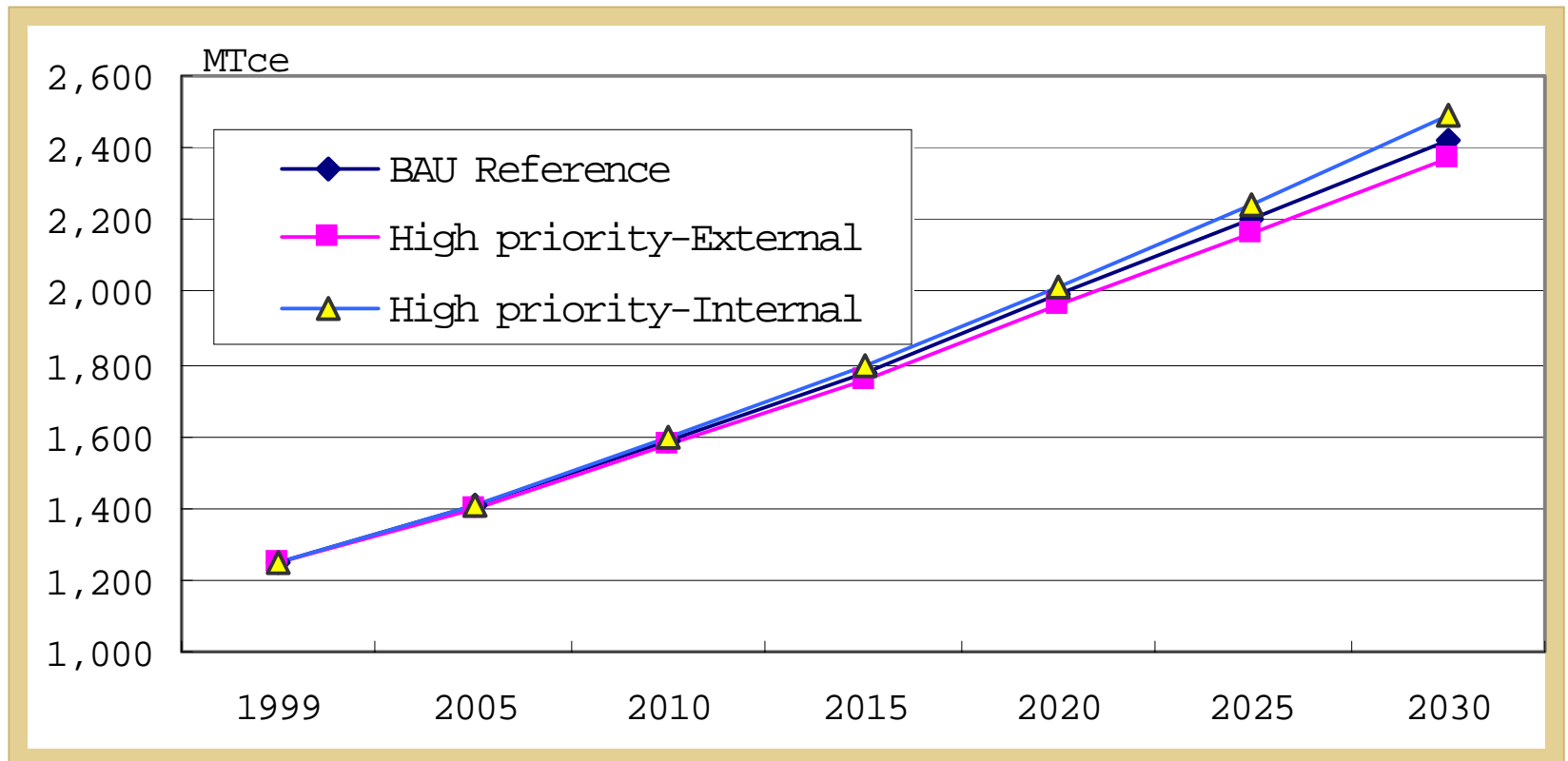
Units: million tonne of coal equivalent

	1999	2005	2010	2015	2020	2025	2030	Avg Annual Growth Rate
Households	386.7	432.1	476.8	524.8	575.3	620.4	662.7	1.8%
Industry	616.5	657.3	719.5	783.3	849.6	919.4	993.7	1.6%
Commerce	59	71.2	82	91.9	102.3	120	139	2.8%
Transport	142.1	186.5	232.2	287.2	352.9	414.6	485	4.0%
Agriculture	41.5	59.2	73.9	91.7	109.5	126.7	143.8	4.1%
Total	1,245.80	1,406.30	1,584.40	1,778.80	1,989.70	2,201.00	2,424.20	2.2%

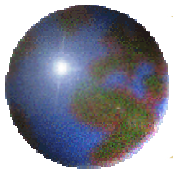
sector energy demand of BAU scenario



MODELING RESULTS

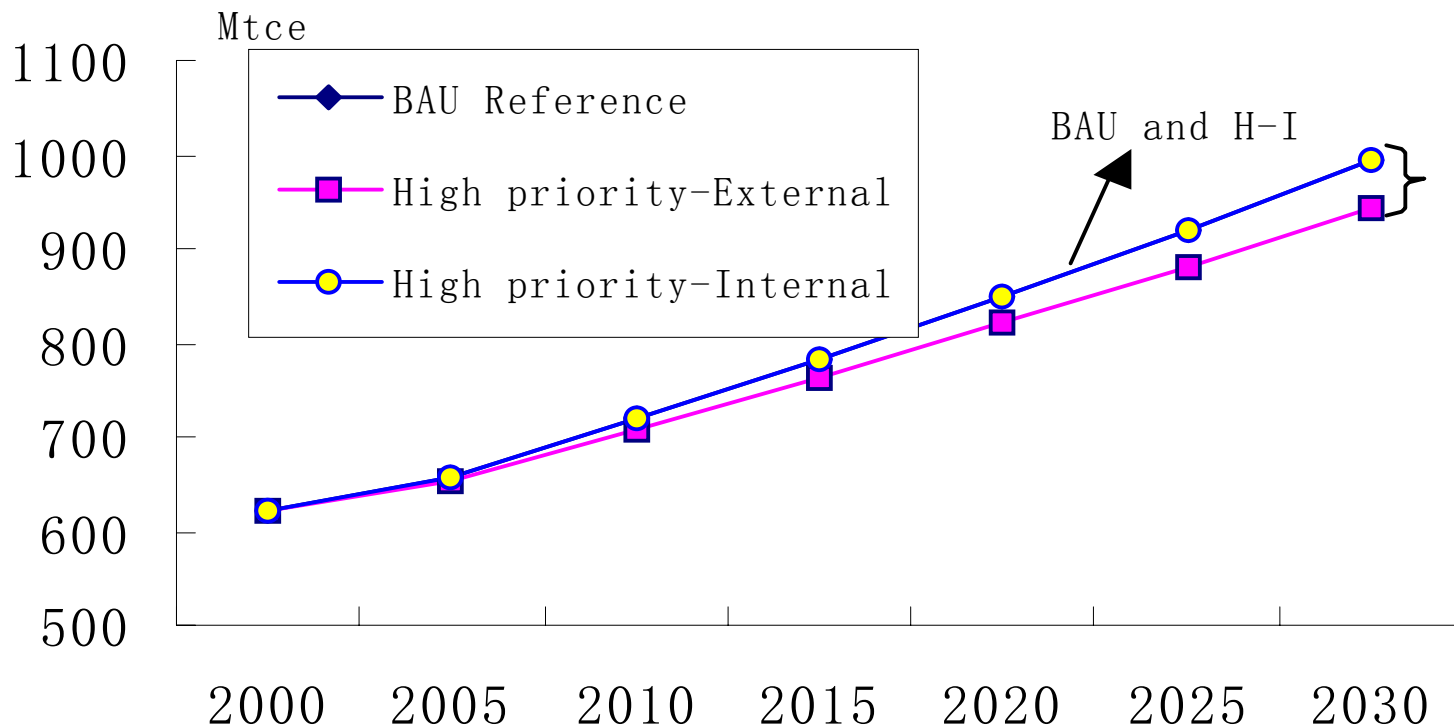


End-use energy demand

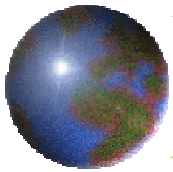


MODELING RESULTS

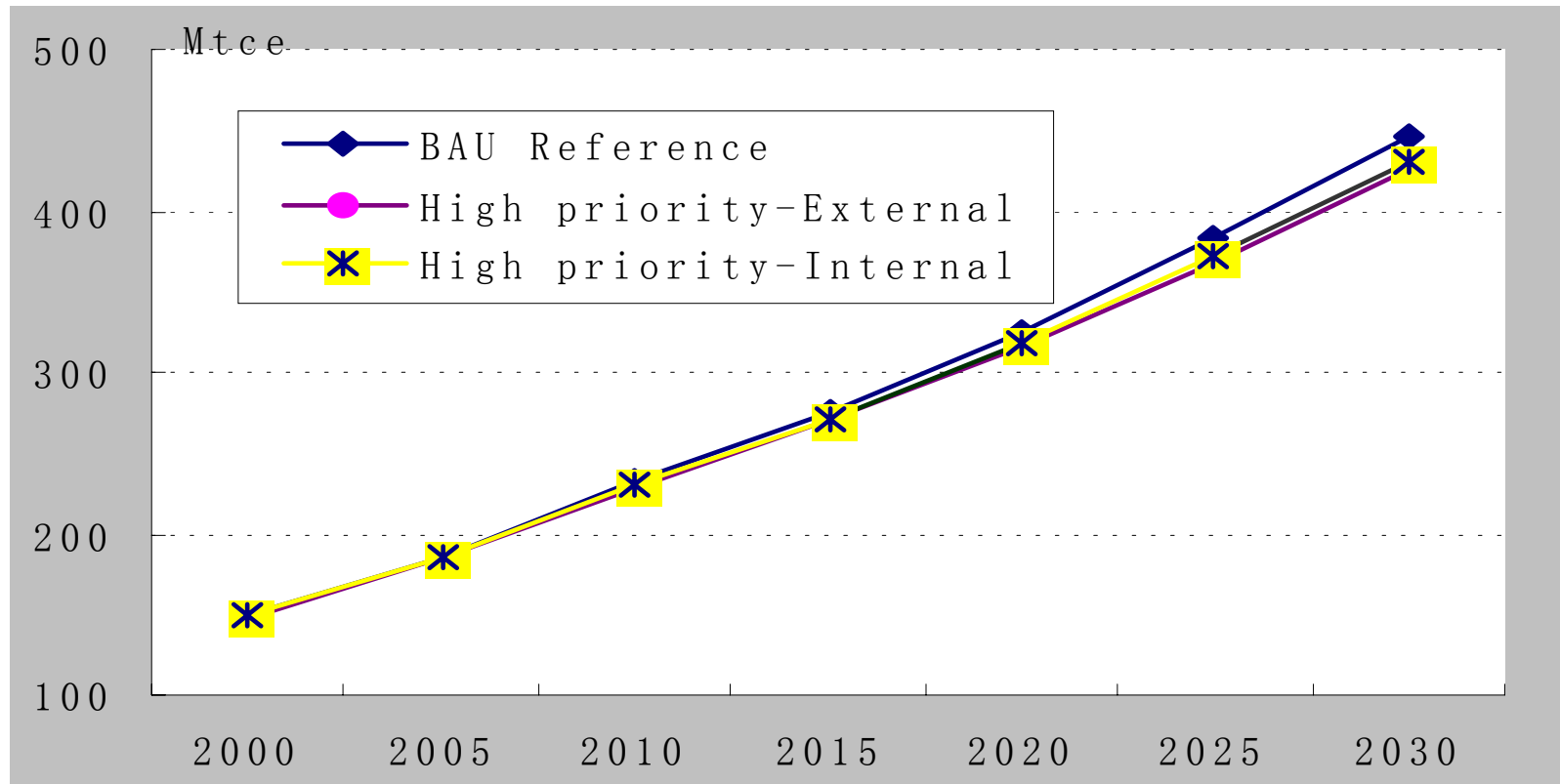
- Overview of the sector energy demand of all the scenarios



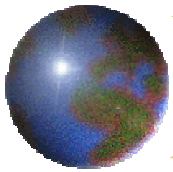
final energy demand in industry sector



MODELING RESULTS



final energy demand of transport sector



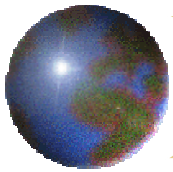
MODELING RESULTS

Overview of electricity generation sector

China: Inputs: processes
 Scenario: High priority-Internal, Business-as-usual, High-priority-External
 Units: million tonne of coal equivalent

	1999	Mix	BAU 2030	Mix	H-I 2030	Mix	H-E2030	Mix
Biomass	0	0.0%	0	0.0%	23.5	2.5%	0	0.0%
Coal	353.4	80.3%	455	52.9%	322.7	33.7%	186.8	23.8%
Hydro	78.8	17.9%	209.3	24.3%	212	22.2%	207.6	26.4%
NG	1.2	0.3%	180.5	21.0%	1.8	0.2%	376	47.9%
Nuclear	4.5	1.0%	14.3	1.7%	382.5	40.0%	14.1	1.8%
Other renewables	0.3	0.1%	0.8	0.1%	13.9	1.5%	0.8	0.1%
Total	439.9	100%	860.3	100%	956.8	100%	785.3	100%

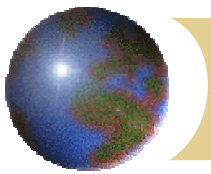
fuel input of electricity generation sector



MODELING RESULTS

China: Outputs: processes							
Units: thousand gigawatt-hour							
	1999	2005	2010	2015	2020	2025	2030
Scenario: Business-as-usual							
Domestic generation total	1,210.90	1,433.80	1,681.70	1,934.50	2,208.10	2,500.20	2,808.00
Import	0.00	15.90	21.70	26.70	34.30	39.70	44.30
Total	1,210.90	1,449.70	1,703.40	1,961.20	2,242.40	2,539.90	2,852.30
Share of Imported electricity	0.0%	1.1%	1.3%	1.4%	1.5%	1.6%	1.6%
Scenario: H-E							
Domestic generation total	1,210.90	1,429.00	1,678.00	1,934.80	2,215.50	2,517.80	2,842.10
Import	0.00	25.60	37.40	49.20	65.80	81.50	97.50
Total	1,210.90	1,454.50	1,715.40	1,984.00	2,281.20	2,599.40	2,939.70
Share of Imported electricity	0.0%	1.8%	2.2%	2.5%	2.9%	3.1%	3.3%
Scenario: H-I							
Domestic generation total	1,210.90	1,443.40	1,701.20	1,965.60	2,256.90	2,578.60	2,930.50
Import	0.00	9.10	9.00	11.10	14.10	14.40	9.10
Total	1,210.90	1,452.20	1,710.10	1,976.60	2,271.10	2,593.10	2,939.40
Share of Imported electricity	0.0%	0.6%	0.5%	0.6%	0.6%	0.6%	0.3%

total electricity supply in each scenario

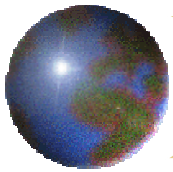


MODELING RESULTS

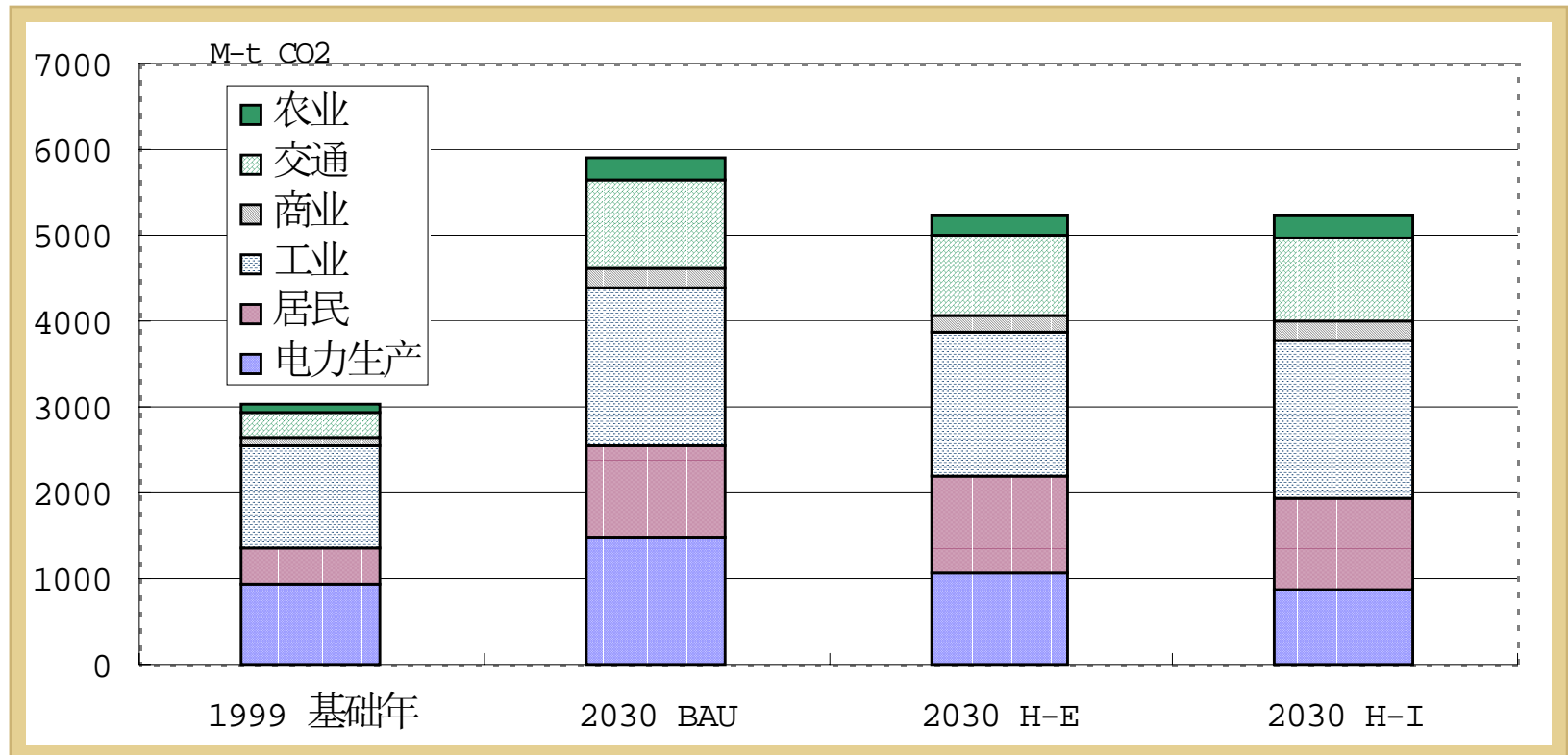
Greenhouse gas emission

Mt CO ₂ :									Change from 1999 to 2030 %		
	1999	Share	2030 BAU	Share	2030 HE	Share	2030 HI	Share	2030 BAU	2030 HE	2030 HI
Electricity generation	944.05	31.3%	1480.89	25.1%	1061.05	20.3%	861.53	16.5%	56.9%	12.4%	-8.7%
Residential	394.88	13.1%	1055.48	17.9%	1125.89	21.5%	1059.17	20.3%	167.3%	185.1%	168.2%
Industry	1194.03	39.6%	1857.43	31.5%	1684.34	32.2%	1857.43	35.7%	55.6%	41.1%	55.6%
Commerce	101.93	3.4%	218.28	3.7%	195.95	3.7%	218.28	4.2%	114.1%	92.2%	114.1%
Transport	301.98	10.0%	1029.88	17.5%	921.04	17.6%	965.96	18.5%	241.0%	205.0%	219.9%
Agriculture	79.45	2.6%	247.31	4.2%	247.31	4.7%	247.31	4.7%	211.3%	211.3%	211.3%
Total	3016.32	100.0%	5889.27	100.0%	5235.58	100.0%	5209.68	100.0%	95.2%	73.6%	72.7%

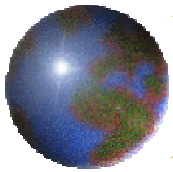
greenhouse gas emission and change from 1999 to 2030



MODELING RESULTS



CO₂ emission

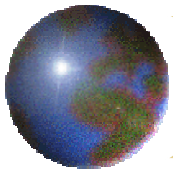


MODELING RESULTS

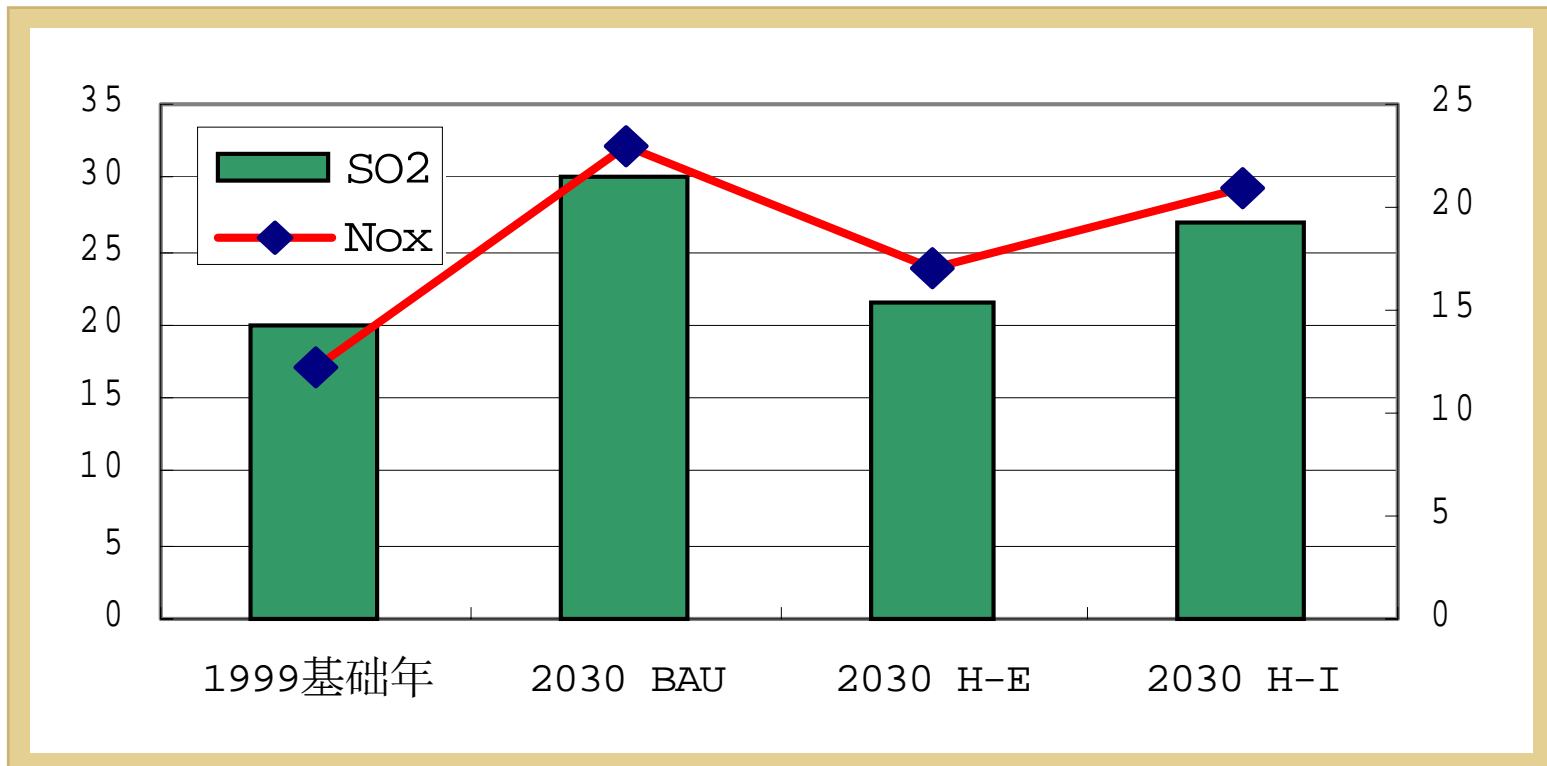
SO₂ and Nox emission

China: SO ₂ and Nox emission						
Unit: million tons						
	SO ₂	V.S.1999	V.S. 2030 BAU	Nox	V.S.1999	V.S. 2030 BAU
1999	20	0%	N.A	12.2	0%	N.A
2030 BAU	30.2	51%	0%	23	89%	0%
2030 H-E	21.6	8%	-28%	17	39%	-26%
2030 H-I	27	35%	-11%	21	72%	-9%

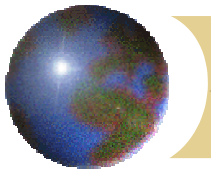
SO₂ and Nox emission in China



MODELING RESULTS

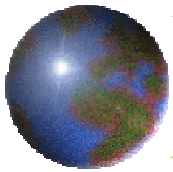


SO2 and Nox emission in China



CONCLUSIONS AND IMPLICATIONS

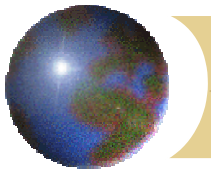
- ❖ **(1)** In the object year 2030, all three scenarios and pathways explored in the paper lead to a more diversified and cleaner energy system relative to base year in China.



CONCLUSIONS AND IMPLICATIONS

- ❖ **(2)** Future technology choices in Electricity generation sector will have significant effect on future primary energy demand composition.

Future energy demand of transporting activities will be a great challenge to China's energy supply

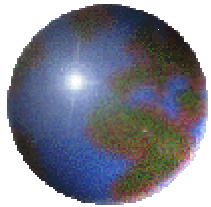


CONCLUSIONS AND IMPLICATIONS

❁ (3) Supply channel and regional cooperation

China is not an isolated island. The tide of regional cooperation has brought both opportunities and challenges.

One possible way to tackle the future risk of supply failure and avoid the embarrassment of policy incompetence is to strengthen regional cooperation and make full use of the resources available in the region at a lower risk and cost



Thank you very much!