

Outlook for Household Energy Demand and its Reduction Potential in Shenyang City, China

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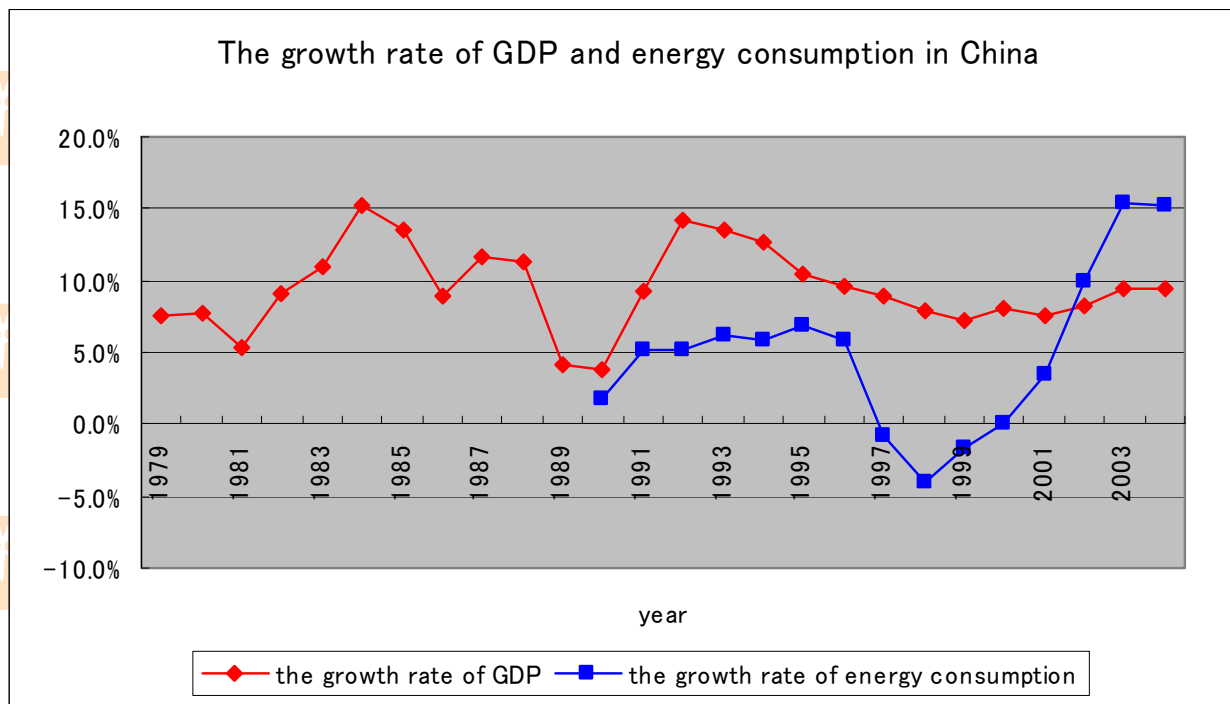
Background

- 1978-2004

The average annual growth of real GDP was 9.8%, and the average annual growth of energy consumption was 4.6%.

- 2000-2020

To keep the average annual growth of GDP as 7.2%, the steady energy supply will be a big problem to china.



Purpose



- Shenyang city, located in the northeast of China, is studied about its energy demand outlook till 2020.
- The effects of different energy saving measures are examined.



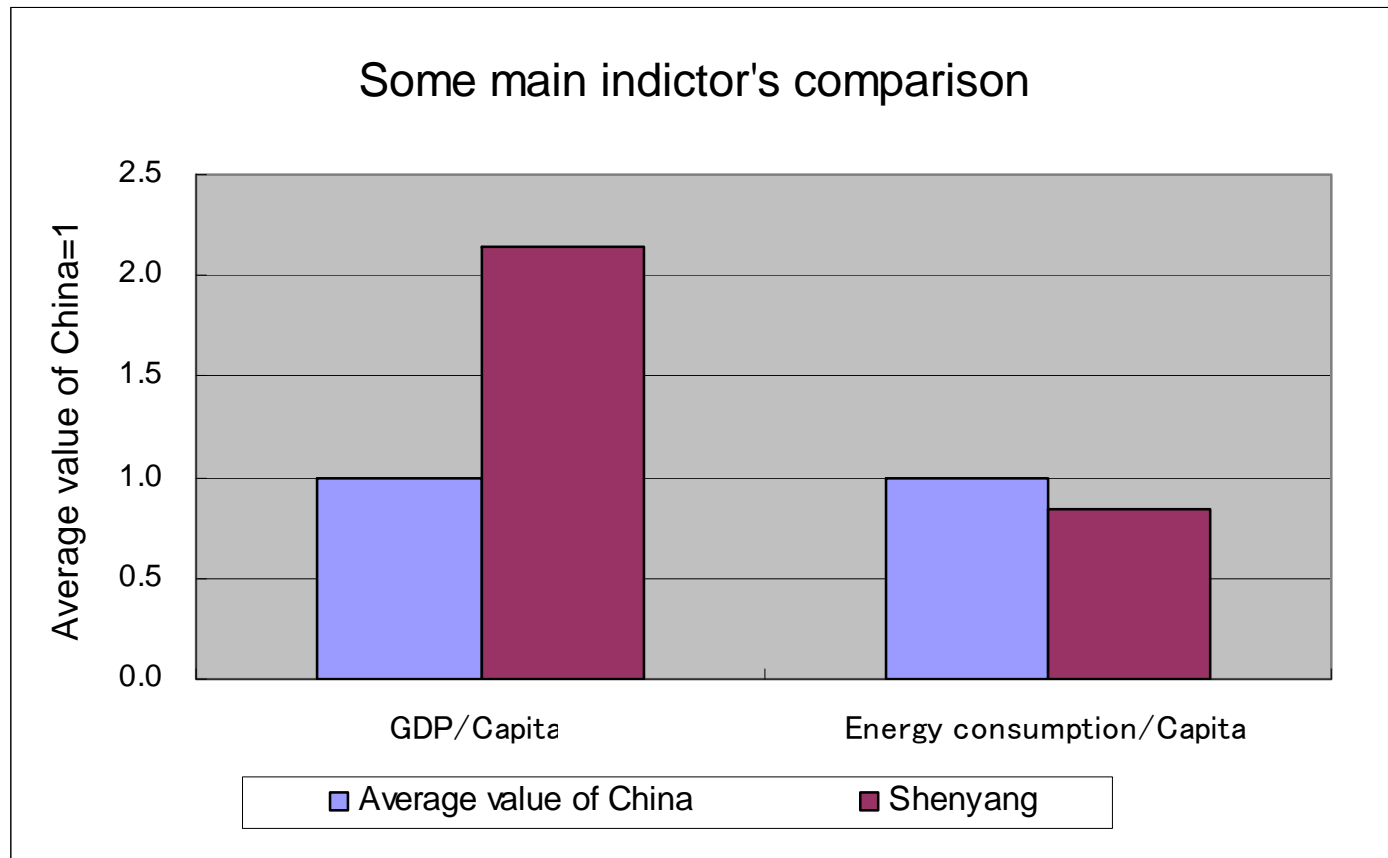
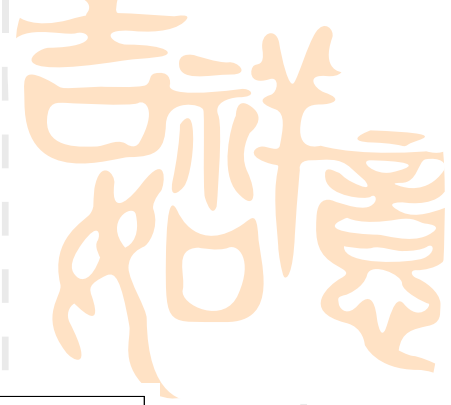
Shenyang City



2005 year

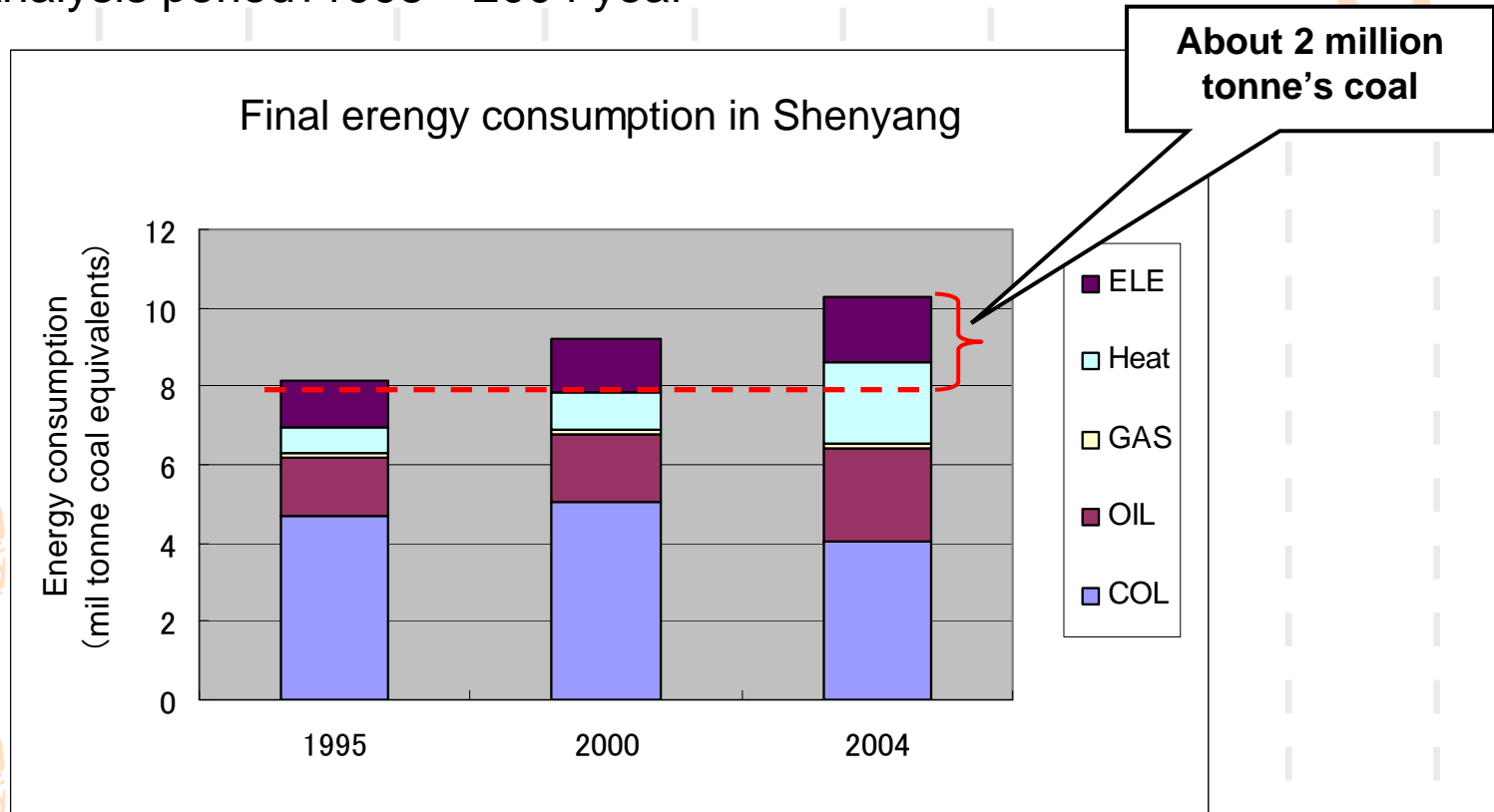
- Population: approx. 7.2 million
- Area: approx. 12,980 km²
- Average temperature of a year: 8.3°C
- Latitude: North 42°
- GRP: 208.4 billion RMB (about ¼ of Liaoning Province)
- Per capita disposable income: 16,393 RMB (the twentieth of big Chinese cities)

Some main indicators



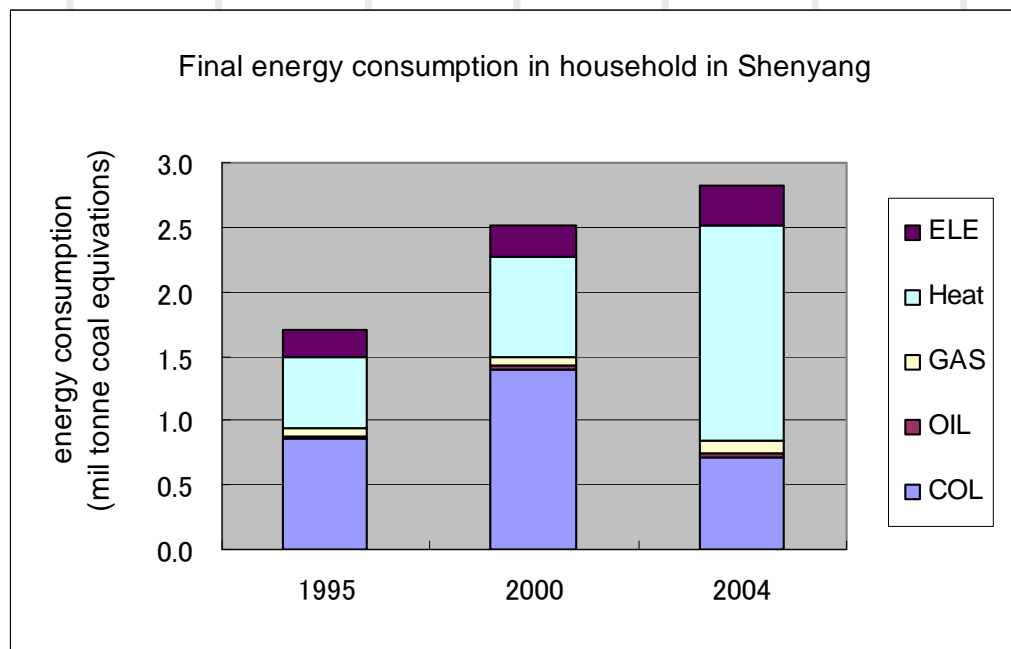
Final energy consumption in the past

Analysis period: 1995—2004 year



- Final energy consumption increased from about 8 mil tonne coal to about 10 mil tonne coal.
- Except coal, all energy increased from 1995 year.

Household energy consumption

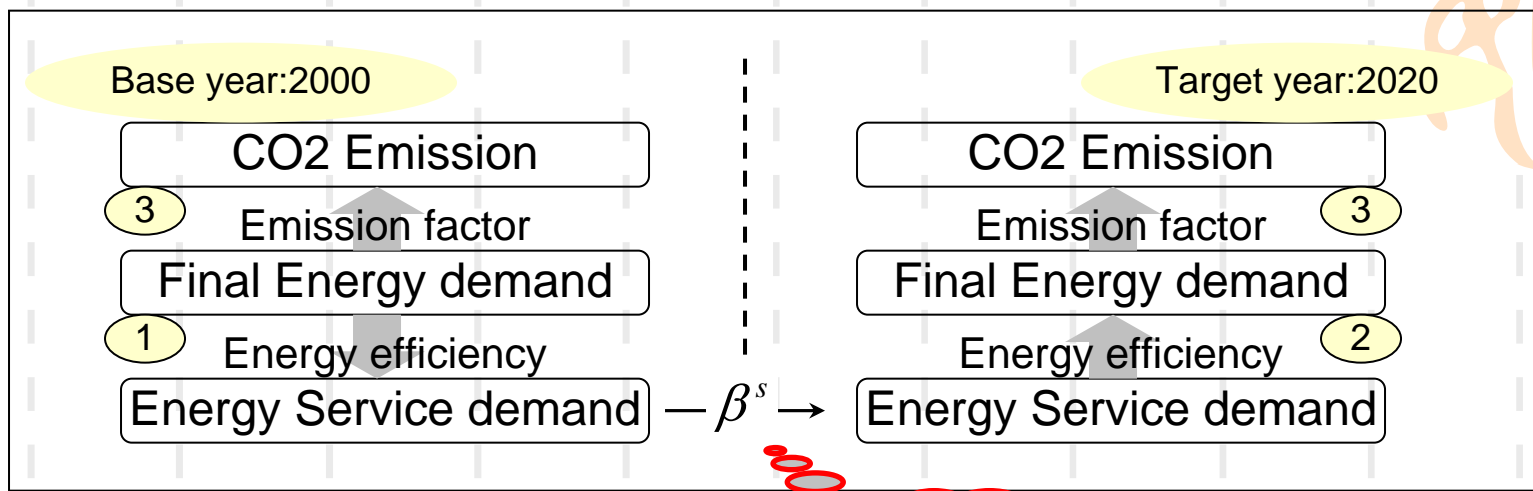


	1980 year	1995 year	2000 year	2004 year
Energy consumption (mil tonne coal equivalents)		1.70	2.50	2.81
Housing floor area (mil m2)	19.00	55.62	75.71	96.33
Coverage of district heating (%)	30	47	53	80

The growth of housing floor area is the most important driver to the increase of energy consumption, and the wide application of district heating changed the structure of energy consumption.



Outlook of household energy demand



$$① ES_{(00)}^s = \sum_e (EC_{(00)e}^s * Eff_{(00)e}^s)$$

$$② EC_{(20)} = \sum_s \sum_e (ES_{(00)}^s * \beta^s * SS_{(20)e}^s / Eff_{(20)e}^s)$$

$$③ EMS = \sum_e (EC_e * Fac_e)$$

e: coal, oil, gas, heat, electricity s: cool, warm, hot water, cooking, light etc.

ES: Energy service demand EC: Energy demand SS: Energy consumption share

Eff: Energy efficiency EMS: CO2 emission Fac: CO2 emission factor

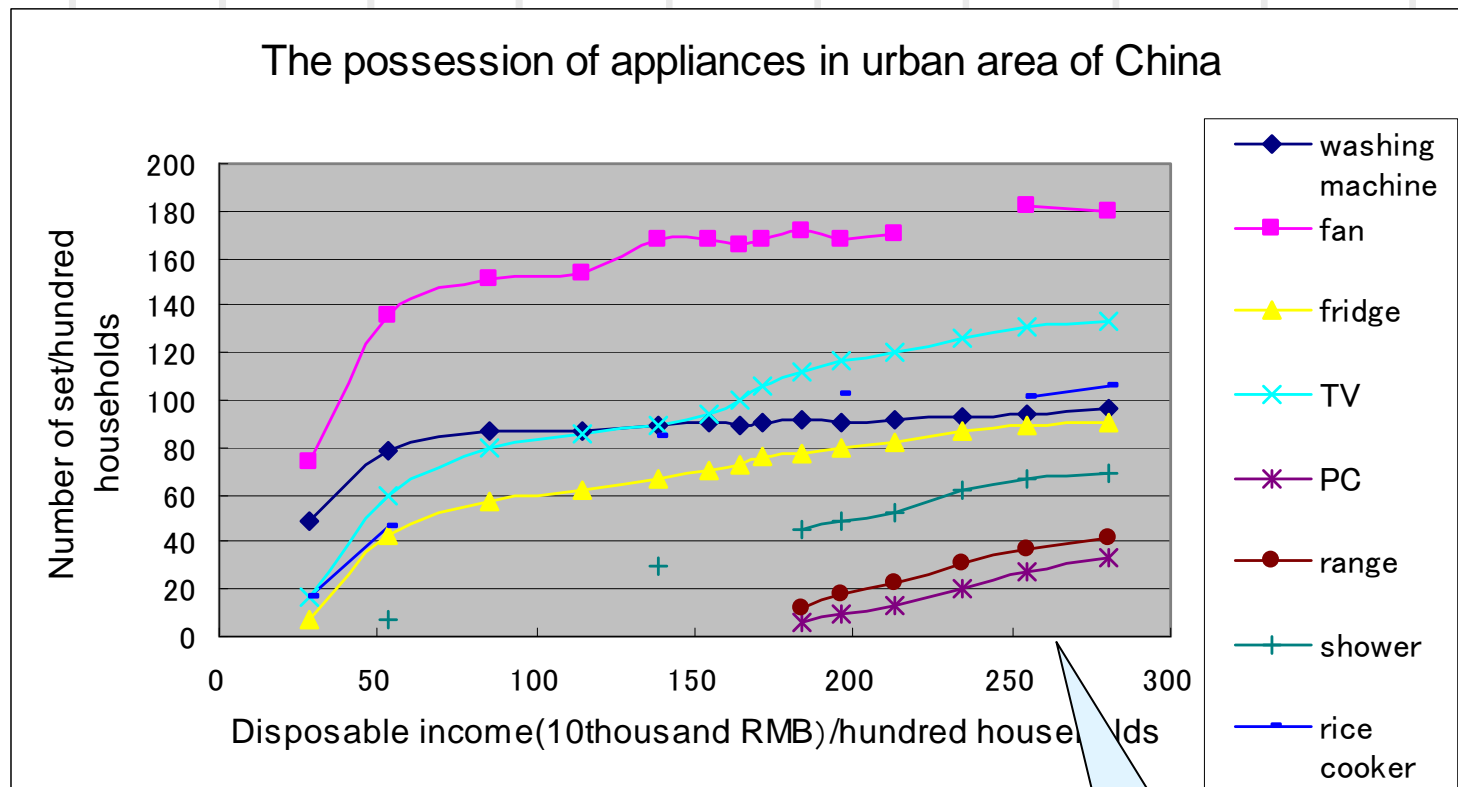
β : the change rate of energy service demand from year 2000 to 2020

Scenario (driving force)

Item	Estimated method	Estimated value (rate of 2000 year)
Population	On a basis of China population growth rate which is calculated by China statistical yearbook, We can calculate the population of Shenyang.	1.13
The number of household	We can calculate the number of household with population and a reduction rate of average household size.	1.22
GDP	With the average annual growth rate of GDP 7.2% till 2020, which is prospected by [The 11th 5-year- plan], we can get GDP of 2020.	4.01
Housing floor area	I calculate floor space/cap based on GDP/cap, and multiply the result by population, then we can get the total housing floor area.	2.05
Coverage of district heating	The coverage will be kept as the level of 2004 year(80%).	1.51
Possession of appliances	On s basis of the tendency of appliance's possession between 1985 and 2004, we can calculate them by items in 2020 year.	1.67
Energy efficiency	To take into account uncertainties, I assume two scenarios: the energy efficiency will increase by 15% and 30% from year 2000.	1.15(BaU1) 1.30(BaU2)

Scenario (driving force)

- Increasing possession of different energy-consuming appliances among urban Chinese households(1985-2004)



Shenyang 2004

Scenario (driving force)

Calculated results for year 2020

X is disposable income/hundred households

Item	formula	Calculated result	Rate to 2000 year
Washing machine	possession = $16.916\ln(x) + 3.2503$	100	1.1
Fan	possession = $40.905\ln(x) - 42.496$	208	1.2
Fridge	possession = $34.399\ln(x) - 101.61$	110	1.4
TV	possession = $48.59\ln(x) - 142.38$	155	1.3
PC	possession = $66.195\ln(x) - 340.03$	66	6.8
Range	possession = $71.5\ln(x) - 360.23$	78	4.4
Shower	possession = $37.867\ln(x) - 148.14$	84	1.7
Rice cooker	possession = $39.495\ln(x) - 113.01$	129	1.3

capacity, operation hours

1.67

Scenario (energy service demand)

- The change rate(β^s) of energy service demand in 2020 year

	Calculation method of energy service demand	Calculated value (rate of 2000 year)
Space heating	Housing floor area * energy service demand/m ²	2.05 * 1
Hot water	The number of household * strength	1.22 * 1
Cooking	The number of household * strength	1.22 * 1
Electrical appliances	The number of household * possession of household application	1.22 * 1.67
Space cooling	Because Shenyang is in the cold area, it is supposed as 0 in the report.	

s:space heating,hot water,cooking,light•appliances,space cooling

Countermeasure scenario



Based on scenario BaU1

■ Countermeasure1(energy-efficient housing)

- Energy-saving level of building: 65%(compared with per square meter energy consumption in 1981)
- Application area: 50% of total housing floor area(77.5 mil m²)
- Increase cost compared with ordinary housing: 6.2 bn RMB
- Warm energy service demand will be cut by 32%.
- Energy-saving/mil RMB: 1.74 mil tonne coal equivalents(MtCe)



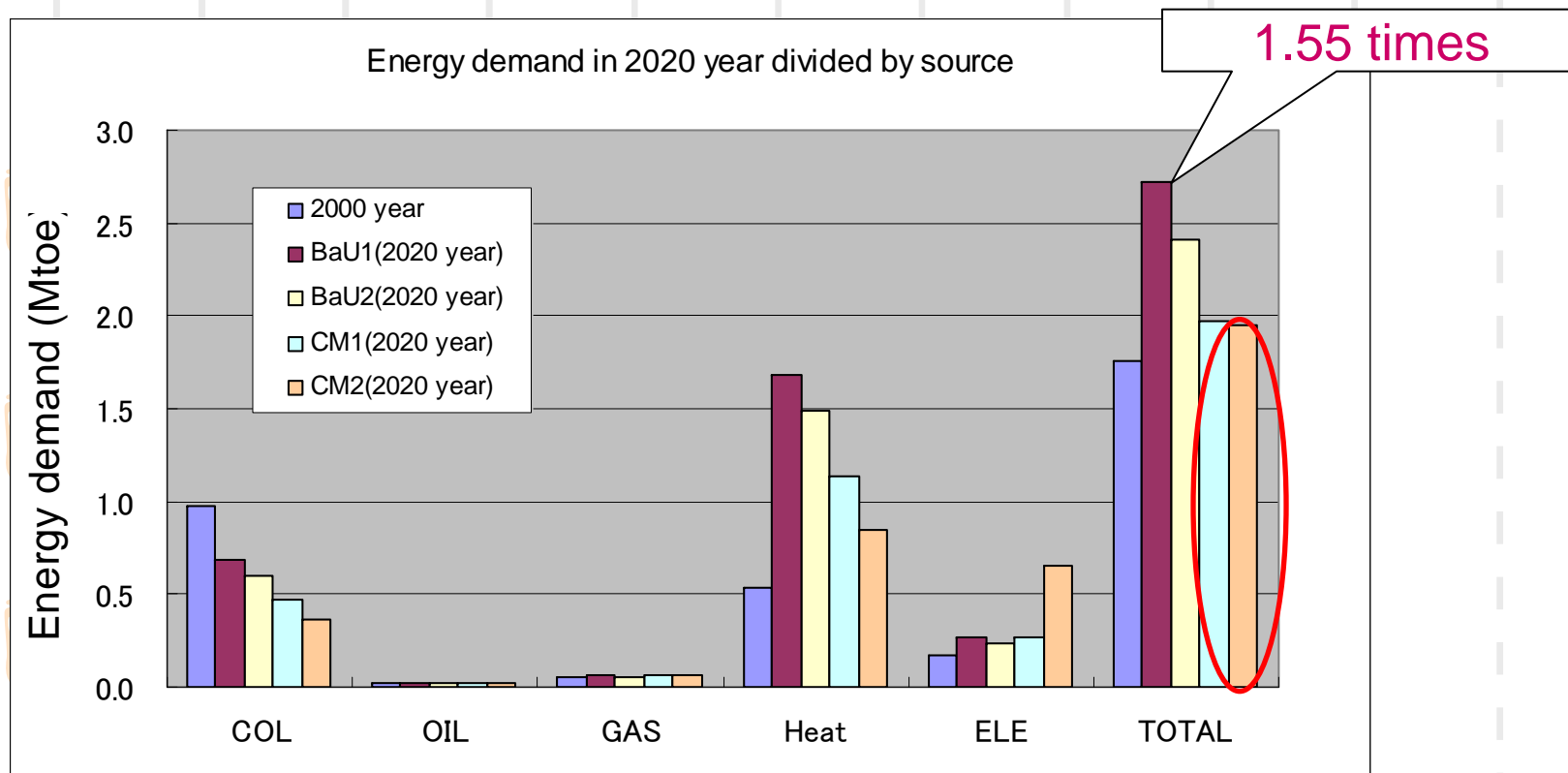
■ Countermeasure2(heat pump)

- COP (coefficient of performance): over 3.0
- Application area: 50% of total housing floor area(77.5 mil m²)
- Increase cost compared with ordinary housing: 15.5 bn RMB
- Energy demand will be cut by 35%.
- Energy-saving/mil RMB: 0.71 mil tonne coal equivalents(MtCe)



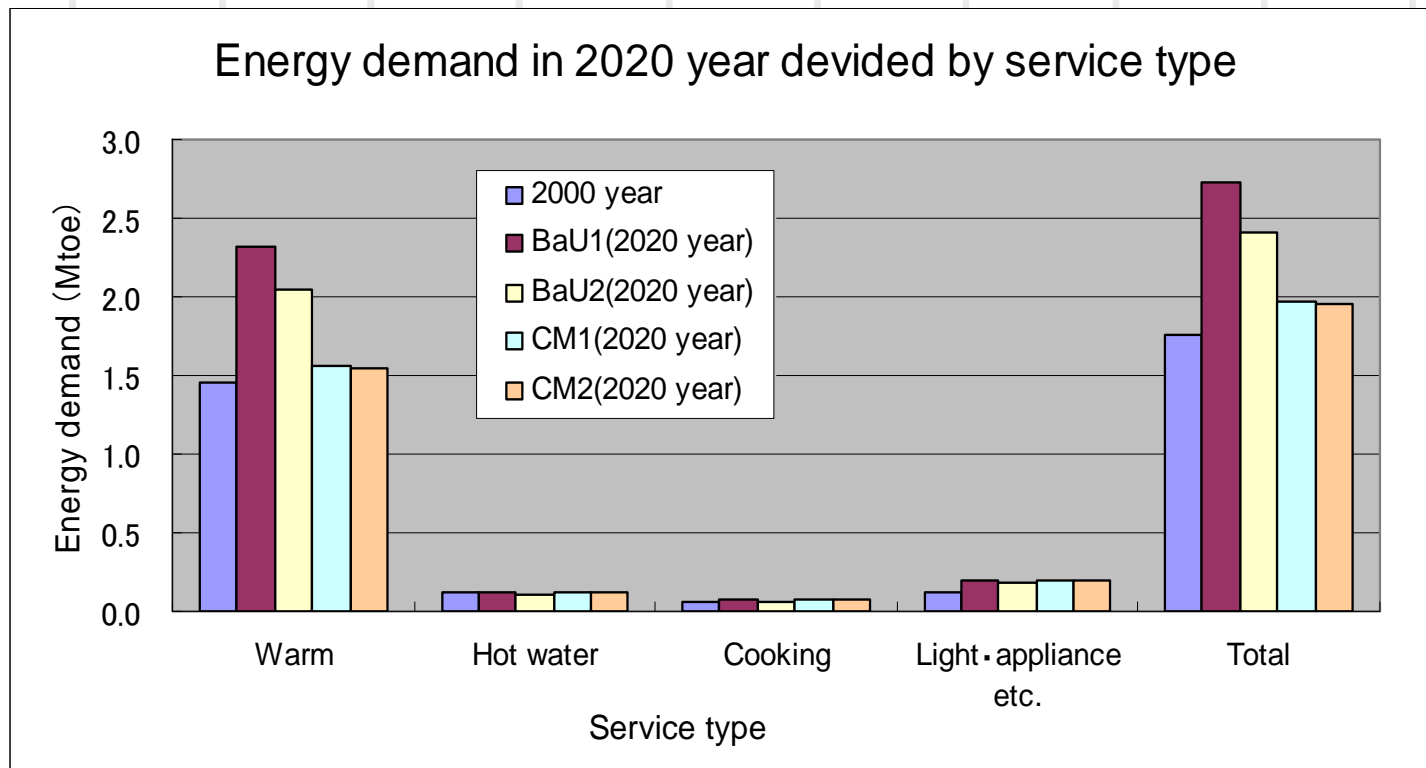
Result 1 (energy demand)

BaU1	BaU2	CM1	CM2
Energy efficiency:15%	Energy efficiency:30%	Energy-saving house	Heat pump
1.55 times of 2000 year	1.37 times of 2000 year	72.3% of Bau1 in 2020 year	71.6% of BaU1 in 2020 year



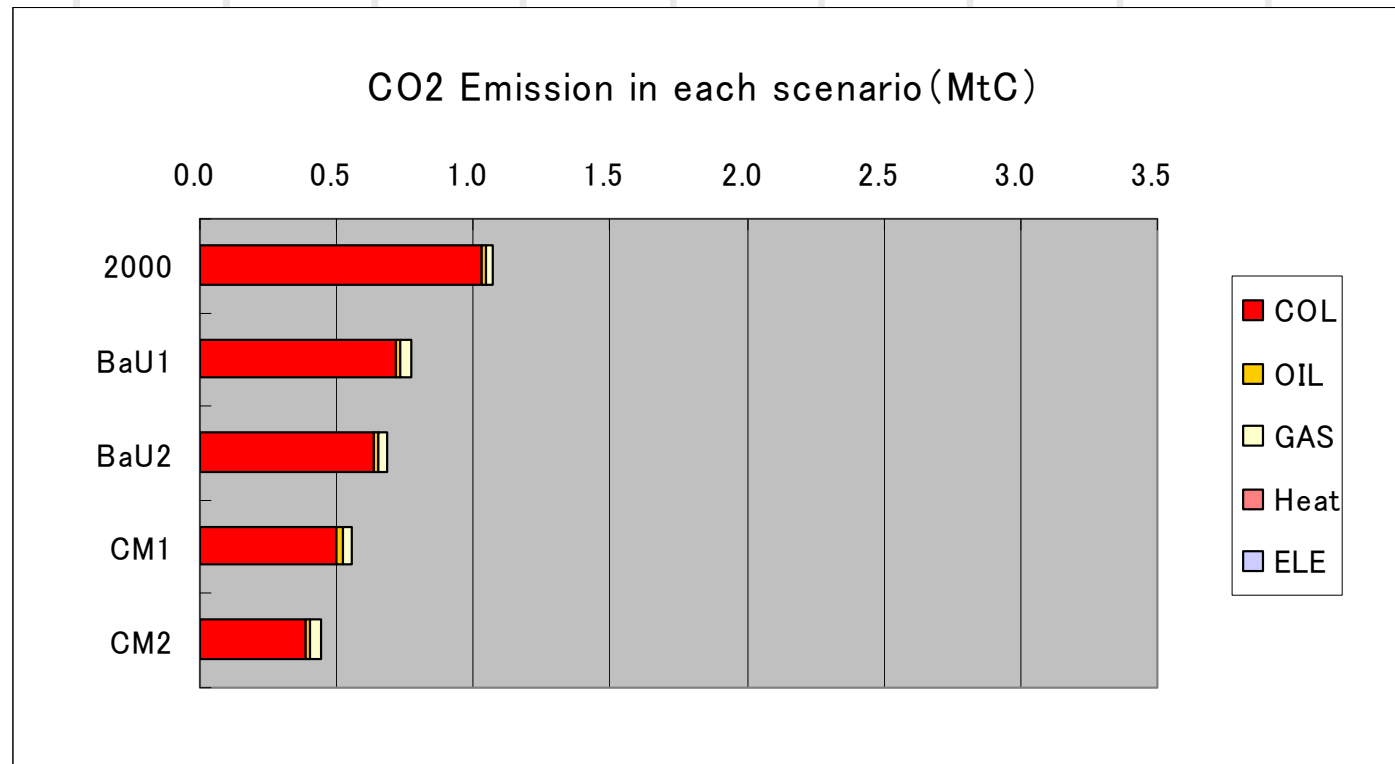
Result 2 (energy demand)

- Warm demand will still take the biggest share of energy demand.
- Energy demand of hot water and cooking will not have a distinct change, because they are almost explained by the number of household and energy efficiency, and the tendency of the two factors just have a conflict change.



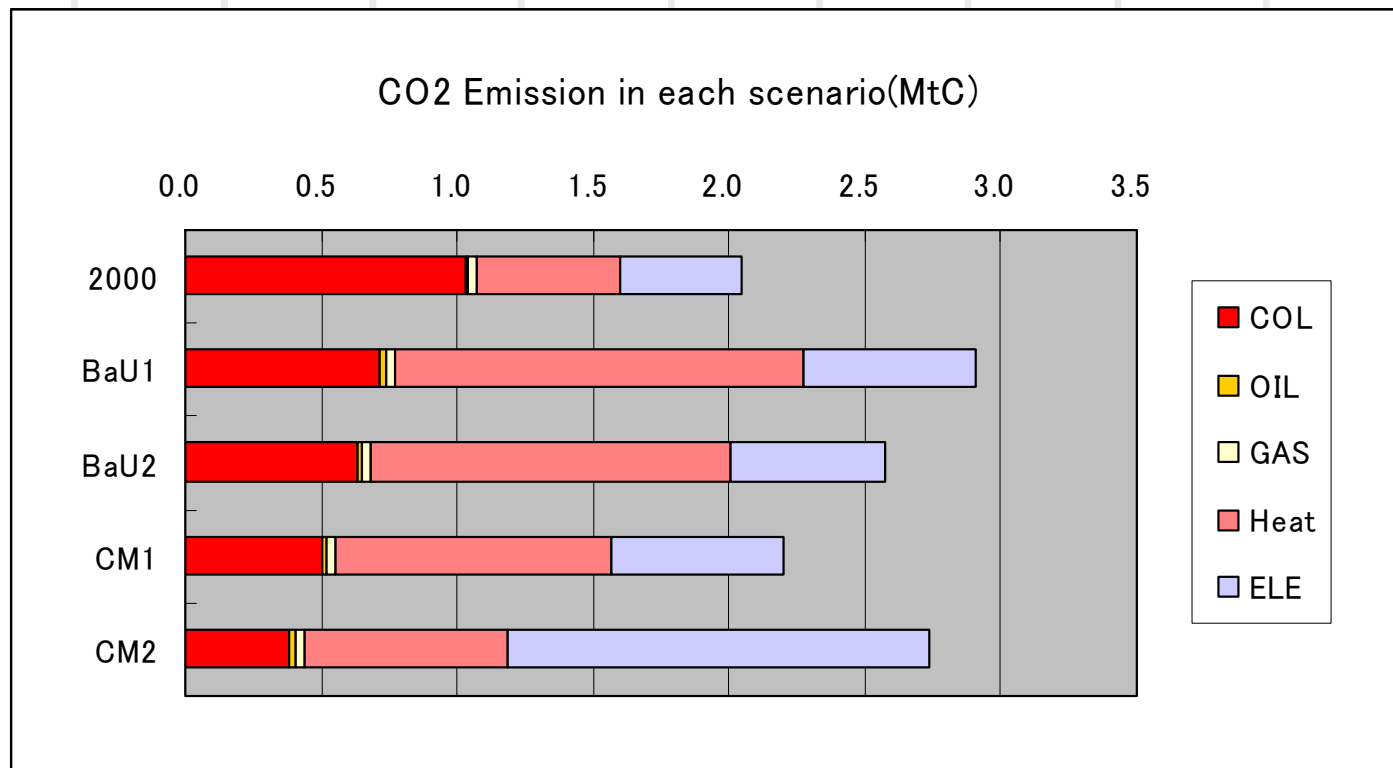
Result 3 (direct CO2 emission)

- Because coal will be greatly replaced by heat, in 2020 year the CO2 emission in BaU1 and BaU2 will be cut to 72% and 64% of CO2 emission in 2000 year.
- In CM1 and CM2, CO2 emission will be cut to 60-70% of BaU1's in 2020 year.



Result 4 (indirect CO2 emission)

- The other hand, in CM2 because of the application of heat pump, electricity demand will greatly rise, if we also count the CO2 emission which is exhausted by electricity supply, there will be not a distinct reduction effect from BaU1 in 2020 year.





Conclusion

- We analyzed the factors of the change of energy consumption in household sector from 1995 to 2004 year. We can say the growth of household space is the most important factor to the increase of energy consumption, and the application of central heating changed the structure of energy consumption.
- Depending on the assumption of energy efficiency, the calculated result of energy demand in household sector in 2020 year is 1.37-1.55 times of that in 2000 year.
- As a effect of energy-saving house and heat pump's application, in CM1 and CM2, the energy demand will be reduced to 72.3% and 71.6% of BaU1(eff increase by 15%).



■ We can say when we implement some energy-saving policy in household sector, the reduction potential of CO₂ emission is large, since our life get better and better.

