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The Impact of Air-Conditioning Use on Shanghai's Energy Situation in 2010

TONGJI UNIVERSITY

LONG Weiding

BAI Wei

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THE CHINA SUSTAINABLE ENERGY PROGRAM

中国可持续能源项目

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I. Economic, Energy and Air-conditioning Situation of Shanghai

i. Shanghai Economic Situation

One of the most important goals of Shanghai socio-economic development is to come into being “the four centers”: the international finance, trade, ship and economic center. Besides that, Shanghai has been making effort to take the lead in building well-to-do society and realizing modernization in China.

In 2004, Shanghai per capita GDP (PPP) is 16,954 USD being 56.7% of the average of the high-income countries. At the same time, the urbanization rate has been 81.2% exceeding the high-income countries. And by the end of 2004, Shanghai total construction area has been 593.14 million m^2 including residential buildings of 352.11 million m2 and public buildings of 124.56 million m^2.

During the 10th Five-Year period (1996-2000), Shanghai’s annual growth rate of GDP is 11.5% and energy consumption per 10^4 yuan RMB GDP is going down from 1.14 tons standard coal in 2000 to 0.93 tons in 2005.

ii. Shanghai Energy Situation

Shanghai has no its own energy resources and had to obtain from other provinces and cities by train and ship. But the energy consumption rate grows year by year. By the end of 2004, amount of Shanghai end-use energy consumption has been 70 million TSC.

In 2005, the maximum of electric power load in Shanghai is 16682MW, greater than the total electricity capacity which is only 13368.4MW. The forecast quantity of natural gas demand is 2 billion m^3 in 2005, but in fact, the actual gettable gas is only 1.6 billion m^3, including 1 billion m^3 from East-West Pipeline and 0.6 billion m^3 from the East Sea Gas Field.

iii. Shanghai Air-conditioning Situation

In recent years, rapid development of economic and urban construction advancing the people’s living quality and expands the Tertiary Industry, and therefore activates the demand of electric-driven air conditioning in Shanghai. Possession of room air conditioner per 100 houses in Shanghai grows at the rate of 36.9% annually and has been 159.2 units. It should be noticed that all of these room air conditioners are

electric-driven.

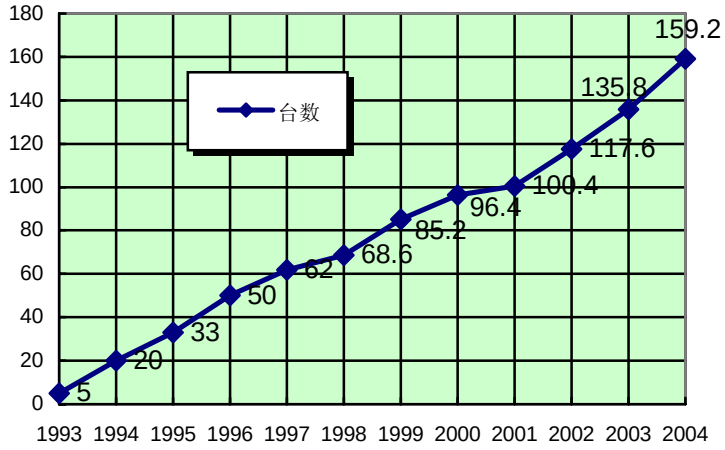

Fig. 1 Growth of possession of RAM per 100 houses in Shanghai

The popularization of RAM is correlational closely with economic and climate, which is shown in the fig.2 and fig.3

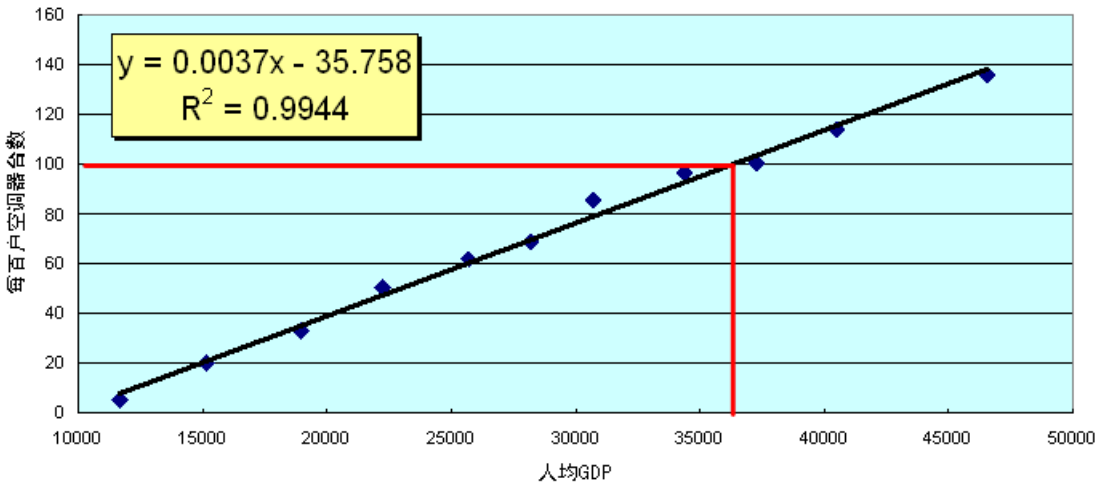

Fig. 2 The linear relationship between per capita GDP and RAM possession of per 100 houses

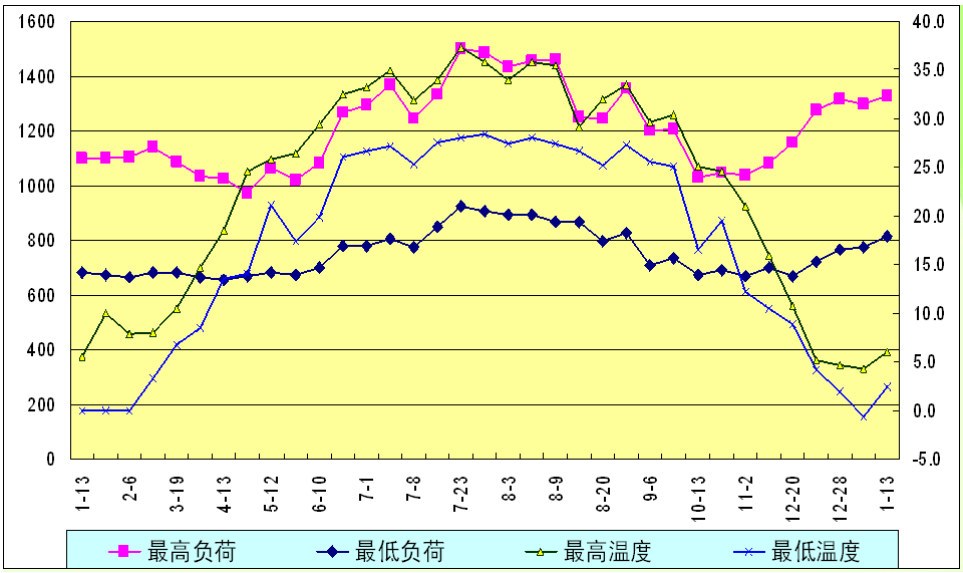

Fig. 3 The direct correlation between power load and climate in Shanghai in 2004

In 2004, Shanghai power load of air-conditioning is 6,860MW up to 40% of the total amount. Popularization of air-conditioning has become the main factor which brings out the peak power load.

iv. Summary

(i) Since all of Shanghai energy resources come from other provinces, cities and countries, it is unavoidable that it would restricted by the energy producing ability, transportation ability and fluctuating market prices.

(ii) It is very necessary to Shanghai to change and modulate its energy structure; the pressure comes from environment and Shanghai socio-economic development.

(iii) Development of modern service and manufacture industries and improvement of people living condition will strike to the structure of electric power load and gas load.

II. The Scenarios Definitions

Three scenarios are defined in this report, respectively called by scenario A, B and C. At the same time, one big background, two main driving variables and three executors are defined and characterized respectively in the three scenarios. One big background is the sustainable development situation, that means, all of the scenarios would be analyzed in this situation; two main driving variables are firm or infirm execution of the sustainable development policies; three executors are government, enterprises and users. The three executors will take different attitudes to policy

institution and execution in different scenario.

Three scenarios are described in detailed as following:

Scenario A, also can be named as **Basic Scenario**, based on China's "11th Five" Planning and ten years society and economic prospects defined by government, assume that the main society and economic goals could be realized. Economic development advances the improvement of energy efficiency. The main executor will act as following:

Government: to keep the present sustainable development policies and do not take any other special measures for energy demand and society effect.

Enterprises: technical and market competition pressure restraining enterprises from input on improving energy efficiency to a certain extent. Most of them just produce products satisfying with market-admittance condition and few produce energy-conservation products with higher energy efficiency.

Users: without strong sustainable development idea, restrained by economic development level, consumption level and ideology, just wish buy and use air-conditioning equipment with low cost with no consideration of energy and environment effect.

Other factors: restricted by cost and resources, etc., clear fuel technology is not popularized extensively enough.

Scenario B also can be named as **Reference Scenario**, based on China's "Eleven Five" Planning and ten years society and economic prospects defined by government, assume that the main society and economic goals could be realized smoothly and government adjust and modulate the relevant policies appropriately. Economic development advances the improvement of energy efficiency at a great extent. The main executor will act as following:

Government: Adjust and modulate the relevant policies on energy demand and society effect appropriately based on the existing sustainable development polices.

Enterprises: the sustainable development policies encouraging and urging enterprises increasing input on improving energy efficiency. But market competition pressure restrains the input at a certain extant. Enterprises would like to produce some energy-conservation products besides producing equipment for satisfying with market-admittance condition.

Users: having some sustainable development idea and also restrained by economic development level, consumption level and ideology. Most consider energy and environment effect at a certain extent when buying and using air-conditioning products.

Other factors: Clear fuel technology is popularized and applied to a certain extent.

Scenario C is a more ideal scenario and can be named as **Strengthened-Policy Scenario**, assume that macro adjustments and improvement of sustainable development policy is very strong and prominent, and government take great acts on improving energy efficiency, economic and energy structure modulation, environment protection and technology progress. At the same time the international environment is also ideal, China can fully get high-quality energy resources from international energy market to make substantive progress on energy structure modulation. China can introduce advanced technology and apparatus from foreign countries smoothly. The energy efficiency level is in a relative leading position in the world in 2020.

Government: Adjust and modulate the relevant policies on energy demand and society effect greatly based on the existing sustainable development polices, stressing the influences on policies of economic, energy and environment, etc.

Enterprises: the sustainable development policies encouraging and urging greatly enterprises increasing input on improving energy efficiency. Technology progress promote enterprises to produce the energy-conserving products further

Users: generally having better sustainable development idea and not be restrained by economic development and consumption level. Most consider fully energy and environment effect when buying and using air-conditioning products.

Other factors: Clear fuel technology is popularized and applied greatly.

III. The Results of Scenarios Analysis

i. Energy Demand

Table 1 Total electric power demand of room air-conditioner in Shanghai

	Total electric power demand 10^4kWh		Peak electric power load 10^4kW 12:00-14:00	
	2010	2020	2010	2020
Scenario A	277498	456714	481	794
Scenario B	266814	425877	462	740
Scenario C	262136	409575	454	712
Power conservation ratio of C to A	5.5%	10.3%	5.5%	10.3%

Table 2 Total electric power demand of central air-conditioning system in Shanghai

	Total electric power demand 10^8kWh		Peak electric power load 10^4kW	
	2010	2020	2010	2020
Scenario A	63.9	70.5	1049	1140
Scenario B	63.2	57.4	1038	943
Scenario C	57.0	51.9	935	851
Power conservation ratio of C to A	10.8%	26.5%	10.8%	25.3%

Table 3 Total power demand and peak power load(12:00-14:00) of air-conditioning of civil buildings in the future

	Total electric power demand 10^8kWh		Peak electric power load 10^4kW	
	2010	2020	2010	2020
Scenario A	224	334	1530	1934
Scenario B	175	235	1500	1683
Scenario C	153	202	1390	1563
Power conservation ratio of C to A	31.5%	39.3%	11.3%	22.6%

Table 4 Details of energy consumption of buildings

	Energy consumption of air-conditioning system 10^4ton SC		End-use energy consumption of buildings 10^4ton SC	
	2010	2020	2010	2020
Scenario A	716	1068	**1364**	**1967**
Scenario B	559	754	**1100**	**1409**
Scenario C	491	648	**970**	**1218**

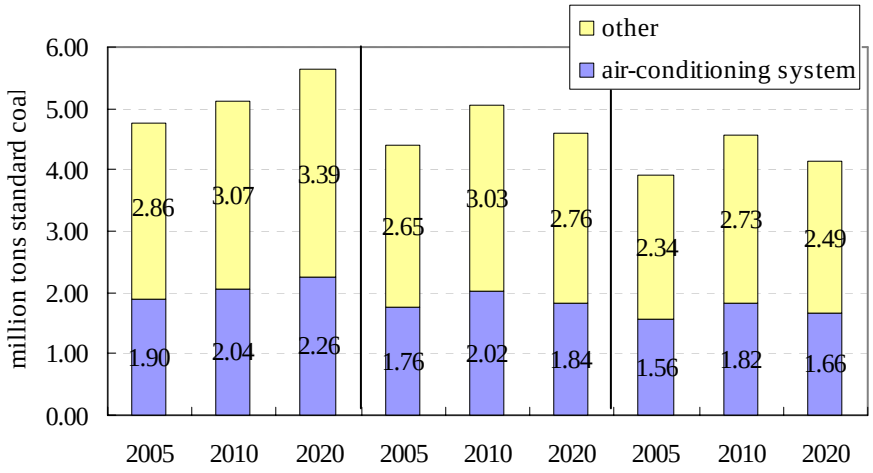

Fig.4 The end-use energy consumption of civil buildings of Shanghai

The total energy consumption amount of Shanghai should be control strictly in the future in order to guarantee the normal and steady development of economy and society because of transport capacity limit. The limit of coal is about 75 million tons (Standard Coal) in Shanghai and in fact, the actual capacity has already been very close to this limit at present. So Shanghai has made strict energy planning in "10th Five" and "11th Five" planning.

In this report, three scenarios are also defined for the future building energy consumption of Shanghai, it's detailed as follows:

Table 5 The future building energy consumption of Shanghai 10^4ton SC

		2010	2020
Total energy consumption amount		**6371**	**7645**
Proportion of building energy consumption %	Scenario A	25%	25%
	Scenario B	28%	28%
	Scenario C	30%	30%
Building energy consumption	Scenario A	1593	1911
	Scenario B	1784	2141
	Scenario C	1911	2294
Proportion of end-use building energy consumption %	Scenario A	16.8%	16.8%
	Scenario B	18.0%	18.0%
	Scenario C	20.0%	20.0%
End-use building energy consumption	Scenario A	**1070**	**1284**
	Scenario B	**1147**	**1376**
	Scenario C	**1274**	**1529**

The result of Scenario A exceeds the limit in energy planning, that means, if Shanghai develops according to the mode of Scenario A, it would encounter very severe energy crisis in the future, even threaten the normal order of socio-economic development and would not realize the sustainable development; but if according to the mode of Scenario C, it would reach the goal and realize the sustainable development of energy and environment smoothly without any special and hard effort.

ii. Environment Effect:

Table 6 The pollutant reduction discharging from room air-conditioner of Shanghai in the future

		2005	2010	2020
Scenario A	10^4 tons			
	SO_2	1.94	2.54	4.17
	CO_2	330.48	431.18	709.64
	NO_x	0.71	0.92	1.52
	TSP	0.12	0.16	0.26
Scenario B	10^4 tons			
	SO_2	1.84	2.44	3.89
	CO_2	312.37	414.58	661.73
	NO_x	0.67	0.89	1.41
	TSP	0.115	0.152	0.243
Scenario C	10^4 tons			
	SO_2	1.70	2.40	3.74
	CO_2	289.67	407.31	636.40
	NO_x	0.62	0.87	1.36
	TSP	0.11	0.15	0.23
Scenario B to A				
Reduction of SO_2 discharge	10^4 tons	0.11	0.10	0.28
Reduction of CO_2 discharge	10^4 tons	18.1	16.6	47.9
Reduction of NOx discharge	10^4 tons	0.039	0.004	0.010
Reduction of TSP discharge	10^4 tons	0.007	0.006	0.018
Scenario C to A				
Reduction of SO_2 discharge	10^4 tons	0.24	0.14	0.43
Reduction of CO_2 discharge	10^4 tons	40.8	23.9	73.2
Reduction of NOx discharge	10^4 tons	0.087	0.051	0.157
Reduction of TSP discharge	10^4 tons	0.015	0.009	0.027

Table 7 The pollutant reduction discharging from central air-conditioning system of Shanghai in the future

		2005	2010	2020
Scenario A	10^4 tons			
	SO_2	5.44	5.84	6.45
	CO_2	924.36	992.79	1095.95
	NO_x	1.98	2.12	2.34
	TSP	0.34	0.36	0.40
Scenario B	10^4 tons			
	SO_2	5.04	5.78	5.25
	CO_2	856.83	981.93	892.45
	NO_x	1.83	2.10	1.91

TSP		0.31	0.36	0.33
Scenario C	10^4 tons			
	SO_2	4.45	5.21	4.74
	CO_2	757.06	885.13	805.71
	NO_x	1.62	1.89	1.72
	TSP	0.28	0.32	0.30
Scenario B to A				
Reduction of SO_2 discharge	10^4 tons	0.40	0.06	1.20
Reduction of CO_2 discharge	10^4 tons	67.54	10.86	203.50
Reduction of NOx discharge	10^4 tons	0.14	0.02	0.43
Reduction of TSP discharge	10^4 tons	0.02	0.00	0.07
Scenario C to A				
Reduction of SO_2 discharge	10^4 tons	0.98	0.63	1.71
Reduction of CO_2 discharge	10^4 tons	167.31	107.66	290.24
Reduction of NOx discharge	10^4 tons	0.36	0.23	0.62
Reduction of TSP discharge	10^4 tons	0.06	0.04	0.11

Table 8 The pollutant reduction discharging from civil building air-conditioning system of Shanghai in the future

		2010	2020
Scenario B to A			
Reduction of SO_2 discharge	10^4 tons	0.16	1.48
Reduction of CO_2 discharge	10^4 tons	27.46	251.41
Reduction of NOx discharge	10^4 tons	0.03	0.45
Reduction of TSP discharge	10^4 tons	0.01	0.09
Scenario C to A			
Reduction of SO_2 discharge	10^4 tons	0.77	2.14
Reduction of CO_2 discharge	10^4 tons	131.53	363.48
Reduction of NOx discharge	10^4 tons	0.28	0.78
Reduction of TSP discharge	10^4 tons	0.05	0.13

iii. Analysis on the Sustainable Development Mode of the Three Scenarios

The analytic results have shown that the basic scenario (Scenario A) is unsustainable development, the reference scenario and the strengthened-policy scenario can be ranked as sustainable development. In the two scenarios, the resource consumption and environment pressure will go down and be dislinked with economic growth while realizing socio-economic development, which can be defined sub-materialized sustainable development.

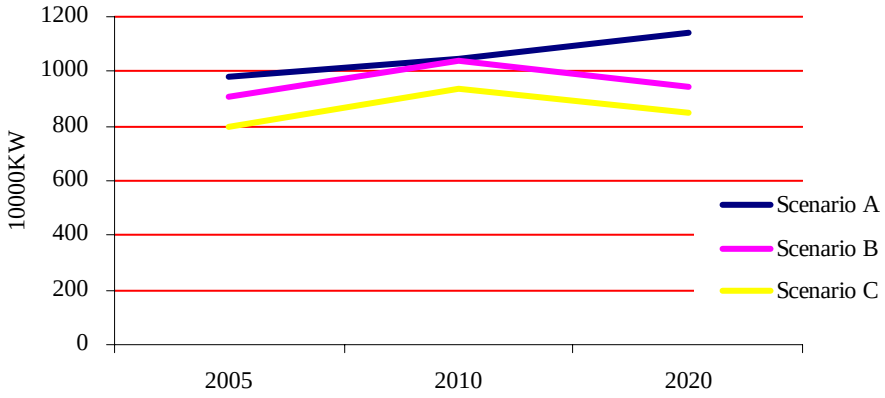

Fig.5 the development trend of peak electric power load of central air-conditioning system in public buildings

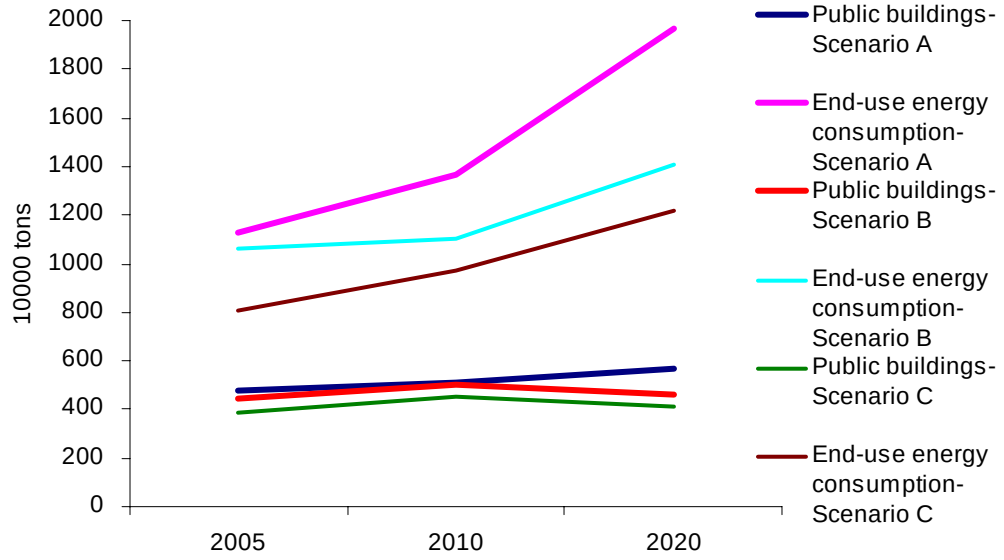

Fig.6 The end-use energy consumption

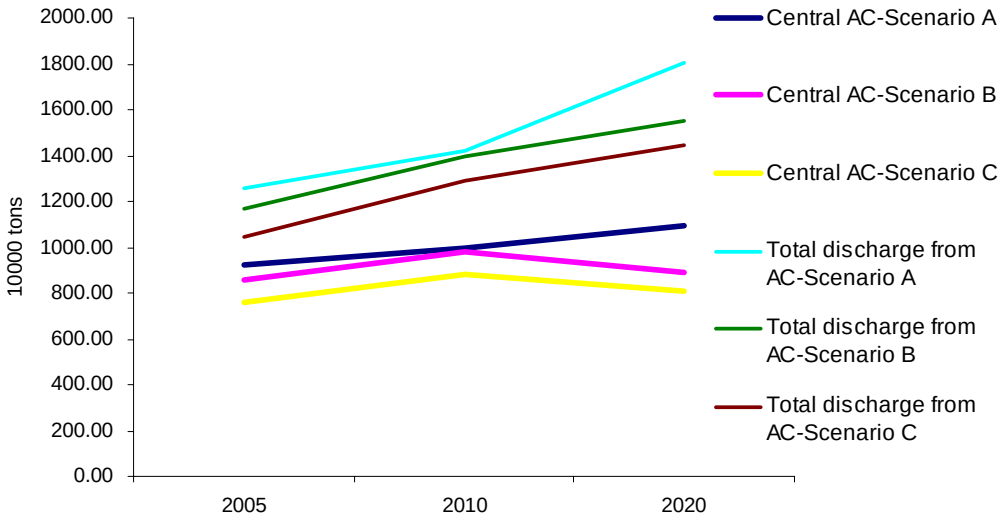

Fig.7 The discharge amount of CO_2 from central AC system in public buildings

IV. Policy Suggestions

i. Advancing Energy Efficiency of Chillers

a. It can not reach the best energy saving goal to constitute uniform energy efficiency grades for piston-, centrifugal- and screw-type chillers, so Shanghai should redefine and stipulate energy efficiency grades for different type chillers based on existing national standard.

b. Shanghai should take the leading in advancing energy efficiency grades of chillers in China. It can choose the higher grade as market- admittance grade in the National Standard, such as the 2nd grade as energy efficiency limit for water centrifugal chiller, the 3rd grade for water screw-type chiller, and stipulate new energy efficiency grades for the rest after inquiring and investigating Shanghai market.

c. Generally, the normal payback period of investment for water chillers is 2-4 years. Shanghai government should give price subsidies to users who buy products with high energy efficiency by the rule. The subsidies can come from income of social department owing to advancing energy efficiency, such as electric department and environmental protection department.

d. Government should take essential administration measures to assure market for products with high energy efficiency. The products reaching energy efficiency grades can be listed on the buying catalogue of government. Contrarily, the products not reaching energy efficiency grades can not be listed on the catalogue. And the energy-saving products can also be given extra favorable score while bidding.

ii. Gas Air-Conditioning

The government should decide whether support or limit development of gas air-conditioning, especially the direct-fired absorption chillers, and it should be based on the local situation of economic, energy and environment to be judged. Economic cost, energy cost and environment cost should be calculated. At the present, Shanghai should slow down promotion of the direct-fired absorption chillers since natural gas supply is very intense. But for the users that have bought the products, Shanghai government should give some favorable policy, such as give some subsidies to compensate their economic loss due to natural gas price growth. Besides that, the

government should do the following:

a. Supervising and urging the energy department to study cutting peak load measures of gas in winter, the gas department to study gas-storage technique in summer and suspensible-user policy in winter, and gathering exports and technical force in HVAC field to carry on research on gas heat pump of seasonal thermal storage and direct-fired absorption chiller burning water coal tar or coal bed gas.

b. Encouraging the development and popularization of gas air-conditioning with high energy efficiency, including gas-driven heat pump, gas-driven centrifugal chiller and gas-driven cooling/heating/power system.

c. Implementing energy efficiency index system of gas air-conditioning and encouraging popularization of gas air-conditioning with high energy efficiency. Mini- and large-scale chiller should be constituted different grades. Shanghai should build local energy efficiency standard and market-admittance limit a little higher than the national standard, and wash out the products with low energy efficiency step by step.

d. Building authentication and supervision system for the energy-saving products, setting up checking organization of gas air-conditioning, making spot testing and publicizing results.

e. Strengthening and promoting social energy-saving idea, propagandizing idea of “energy-saving, electric-saving, environment protection” by public media, popularizing energy efficiency index system, and vigorously propagandizing energy efficiency of gas air-conditioning for users. Only if users know that economic income of gas air-conditioning from energy-saving can offset price difference, they would buy the products with high energy efficiency.

iii. Building Cooling/Heating/Power

a. Constituting favorable policy of electric power merging into public network for BCHP, regarding distributional power as ”green power” and giving users actual profit. So according to the present power price, the purchasing price should not be lower than 0.40YUAN RMB/kWh. Shanghai should use economic lever to promote development of BCHP.

b. Continuing the subsidies given to BCHP users. The subsidies should be 10% of

first cost of BCHP equipments. At the same time, Shanghai should regulate the price ratio of power to gas to about 4.9 in order to guarantee economic efficiency of BCHP system.

c. Developing district Heating/Cooling/Power system and fuel cell system and building as soon as possible several demonstrative projects, such as Shanghai EXPO ‘2010 projects.

iv. Reducing Use of Air-Cooled Unit with Low Energy Efficiency

a. Advancing EER of air-cooled chiller further, for example, to the 2nd grade of <Energy Efficiency Grades Standard of Chiller (GB 19577-2004)>

b. Asking designers choosing water chillers with higher energy efficiency as far as possible, especially for large-scale buildings; stipulating to equip water chillers with COP larger than 4.10, strictly prohibit VRV used in the large-scale building.

v. Target and Standard of Public Building Energy Efficiency

a. Strengthening supervision and implementing energy efficiency standards strictly to assure the basic technique requested in the standards can be put into practice.

b. Fixing on energy efficiency target with the limit of future building energy consumption, modulating dynamically energy-saving quantity and constituting energy-saving measures according to annual growth rate of building energy consumption. The constitution should be based on the general level of energy efficiency and energy consumption of the present buildings. New buildings, large-scale public buildings and heating buildings are the most important objects for realization of energy efficiency target, it is a basic rule.

c. In this report, the Scenario B and C are be defined sustainable development, they realize sub-material of energy consumption and environment demand while socio-economic growth. Therefore, if Shanghai go according to Scenario C, it would reach the goals set in the energy planning without any special and hard effort.

d. Taking the value of peak power load reduction as the target of energy-saving and guiding by energy policy.

e. Guiding the technologies that can reduce peak power load and smoothen power demand in buildings and taking into account as a whole in energy plannings. The

technologies include thermal storage, gas air-conditioning, direct-fired absorption chillers, etc.

f. Giving favorable policy, such as economic compensation or tax bite, to the users of gas air-conditioning, thermal storage and BCHP.