



***Scenario Analysis on Low-Carbon Economy
Development of Jilin City***

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1 Social Economic Development of Jilin City

In 2007, the population is 4.33 million in the city, 4.8% more than that in 1990, with no significant increase basically. Among them, the urban population is 1.82 million, accounting for 42%, while non-agricultural population is 2.11 million, accounting for 49%, with a 5% increase compared to 1990. There are 1.44 million households, 32% more than that in 1990, and the average number of persons per household is 3.01 (see Table 1).

Table 1: Population of Jilin City

Year	Household (10,000 Households)		Population (10,000 capita)		Capita per household (capita)	
	Whole city	Urban district	Whole city	Urban district	Whole city	Urban district
1949	37	6	164	28	4.48	4.5
1970	64	16	320	79	4.99	5.03
1975	73	18	358	89	4.94	4.83
1980	85	23	386	102	4.57	4.6
1985	95	29	395	114	4.14	3.87
1990	109	36	413	127	3.8	3.55
1995	116	39	425	138	3.66	3.51
2000	145	53	432	179	3.46	3.38
2005	137	58	429	180	3.12	3.09
2006	141	59	430	180	3.05	3.03
2007	144	61	433	182	3.01	2.98

Jilin has experienced a rapid economic development during the past 20 years, with the increase rate of 10.6% from 1990 to 2007 and 11.6% from 2000 to 2007. In recent three years, the increase rates of GDP in Jilin are 16.5%, 17.3% and 14.3%. In 2007, the GDP of the city is 130.02 billion (see Figure 1 and Figure 2), and ratio of three industry structures is 13.5: 49.3: 37.2, the change of which can be seen from Figure 3.

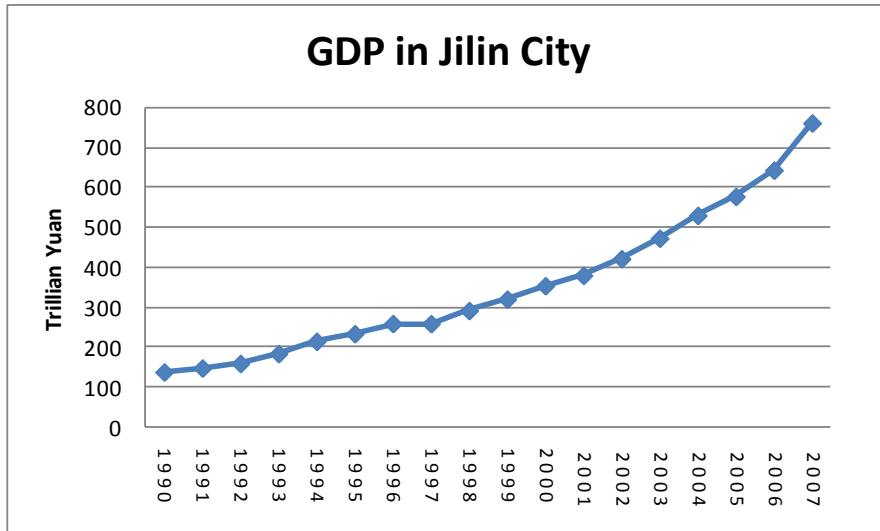


Figure 1: The Development of Jilin

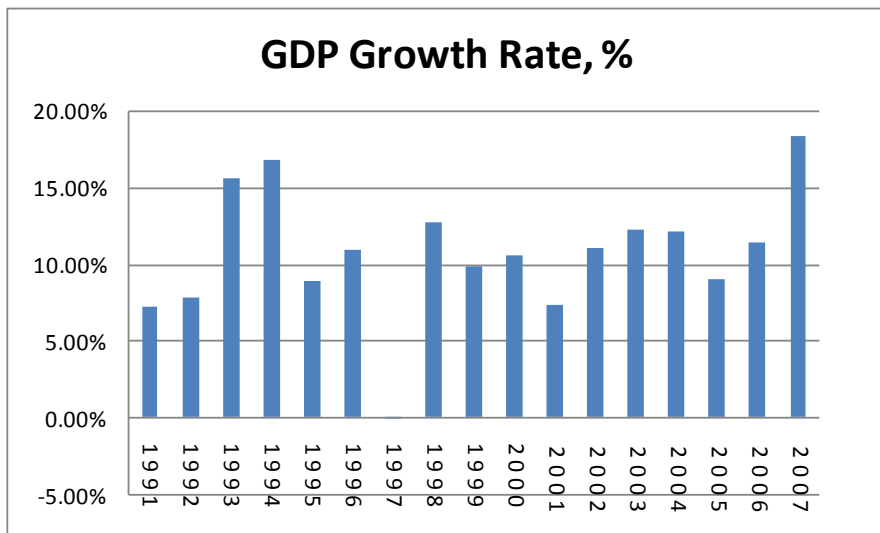


Figure 2: The Increase Rate of GDP

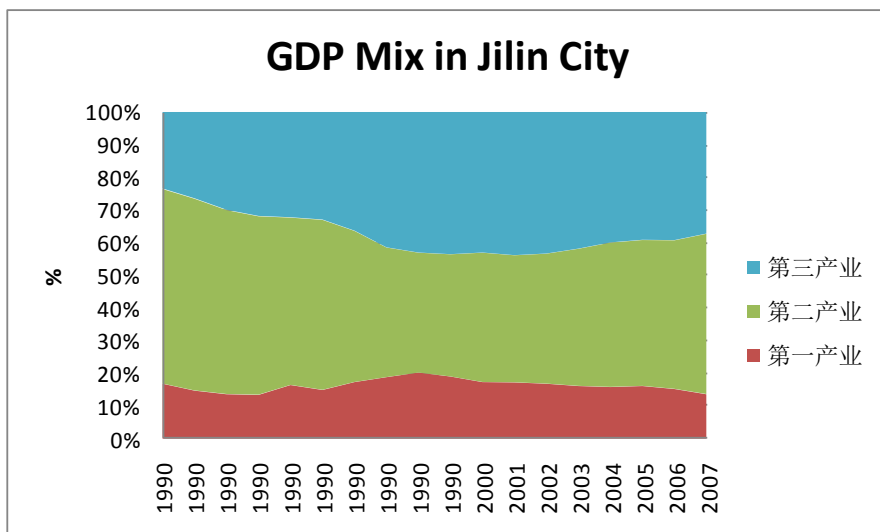


Figure 3: The Change of GDP Structure

2 Energy Consumption and Supply of Jilin City

In 2007, the total installed capacity of public power plants in Jilin City was up to 4.6 million kW, accounting for 1/3 of total installed capacity in Jilin province. Among them, hydropower was 3.023 million kW, accounting for 34%, while thermal power was 1.577 million kW, accounting for 66%, with an annual power generation of 12.95 billion kW. There are one primary substation of 500 kV, 11 public primary substation of 220 kV, and 30 public secondary substation of 66 kV in the power network in Jilin. Jilin has built the largest fuel alcohol plant in Asia in 2002, with a productivity of 5 million ton, which was newly enlarged, and now it can process and transform 150 ton of maize. In addition, the output of coal in Jilin was 3.35 million ton in 2007, the natural gas supply was 34.82 million m³, and the output of coke, gasoline, diesel oil and fuel oil were 0.176, 1.0797, 2.67 and 0.33 million ton respectively. In 2007, the sales income of energy industry of Jilin was 26.85 billion Yuan, and the profits tax was 1.59 billion Yuan, accounting for 22.4% and 15.7% of sales income and profits tax of over scale industry. Thus, the energy industry now becomes the second pillar industry of Jilin, after the chemical industry.

The energy production of Jilin in the past years can be seen from Figure 4. During 2000 and 2007, the annual increase rates of energy production are 8% for raw coal, -1% for coke, 5% for power generation, 4% for gasoline, 15% for diesel oil and -13% for fuel oil, which means the production of raw coal, power generation, gasoline and diesel oil increase while the production of coke and fuel oil decrease.

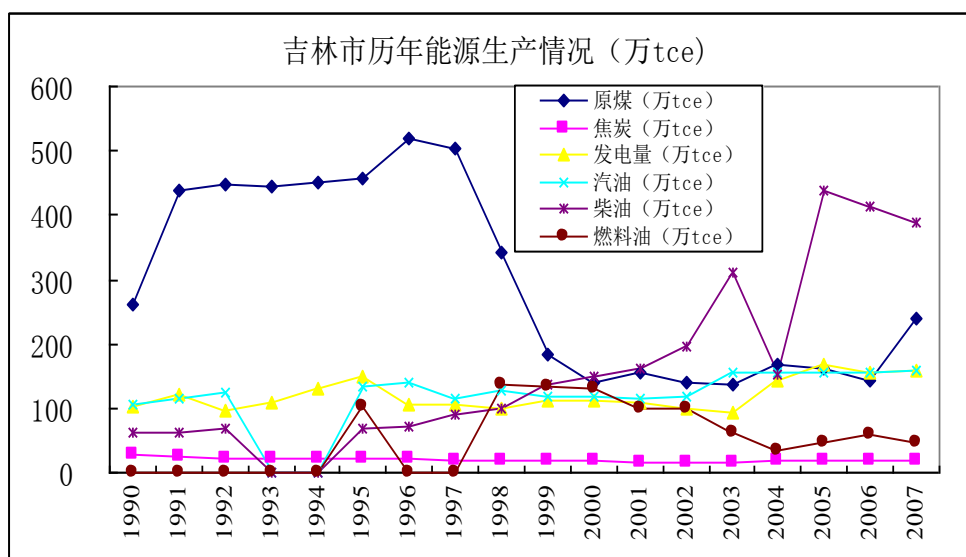


Figure 4: Energy Production in Jilin City

In 2007, the total primary energy consumption is 1.563 million ton standard coal, in which the consumption of raw coal, raw oil, natural gas and hydropower are 8.331 million tce (accounting for 59.2%), 5.404 million tce (accounting for 38.4%), 0.028 million tce (accounting for 0.2%) and 0.308 million tce (accounting for 2.2%) (see

Figure 5). In 2007, the final energy consumption of Jilin is 12.9236 million tce, in which the consumption of coal, oil, natural gas, electricity and thermal are 3.392 million tce, 5.2646 million tce, 0.0279 million tce, 1.5478 million tce and 2.5748 million tce (see Figure 6). The energy consumption of the first industry, second industry, third industry and households are 0.322 million tce, 9.787 million tce, 1.564 million tce and 1.25 million tce. The energy consumption of agriculture, industry, architecture, transportation, service and residents are 0.322 million tce (accounting for 2%), 9.66 million tce (accounting for 75%), 0.127 million tce (accounting for 1%), 0.383 million tce (accounting for 3%), 0.374 million tce (accounting for 3%), 1.25 million tce (accounting for 10%).

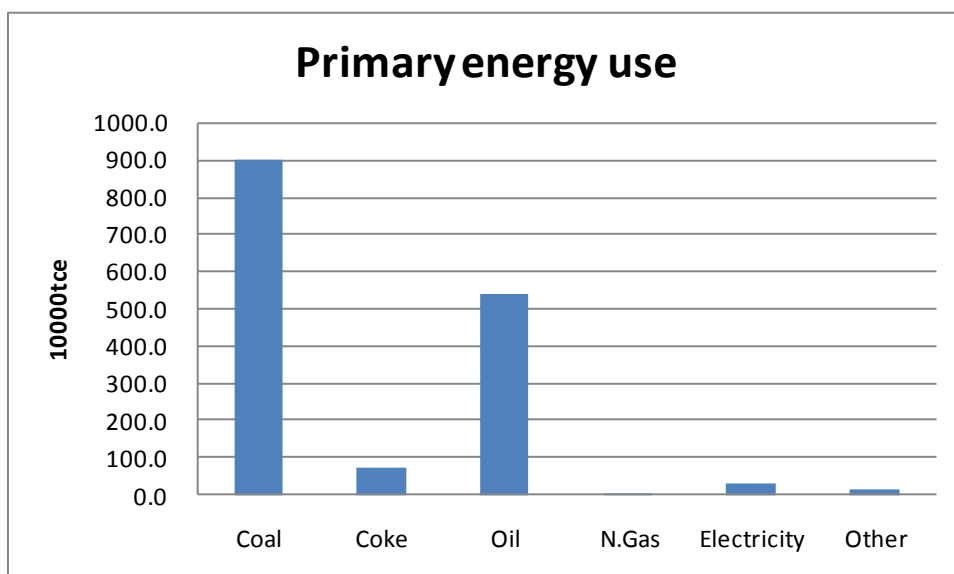


Figure 5: Primary Energy Use of Jilin City

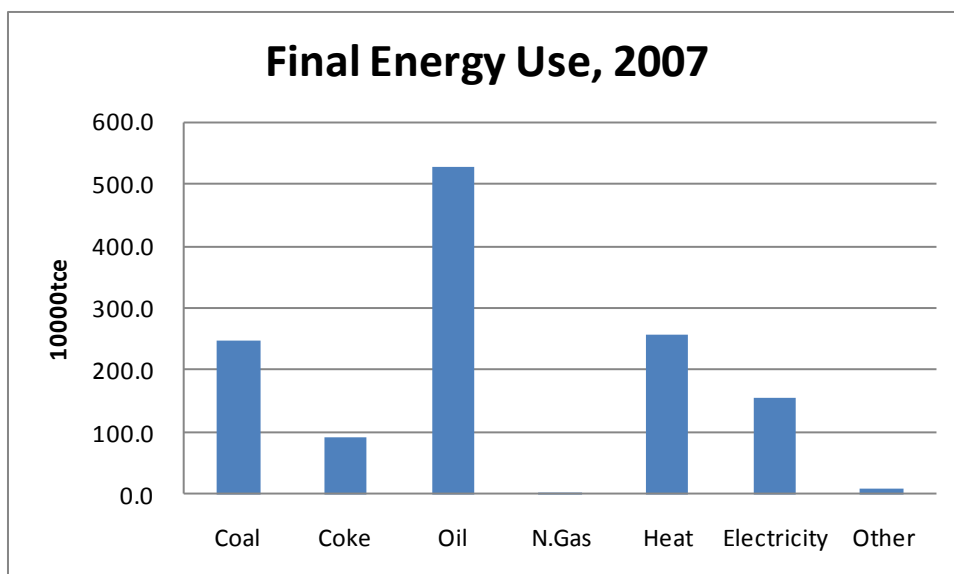


Figure 6: Final Energy Use of Jilin City

Jilin is an old industrial base mainly depending on heavy industry, with the energy

industry as the pillar industry, while the power industry and coal mining industry are main energy industries. By the end of 2007, the total installed capacity is 4.6 million kWh, accounting for 10% of the Northeast Power Network, and 45% for Jilin province. Among them, the thermal power and hydropower are of 2.90 and 1.7 million kWh, while the total amount of power generation of Jilin City is 12.9 billion kWh and the total power consumption is 12.5 billion kWh. There are 10 substations of 220 V, with a total capacity of 193 kV, and 110 substations (transformer towers) of 66kV, with a total capacity of 1.5 million kV. The state of energy supply and consumption by different sectors can be seen in Table 2.

Table 2: The State of Power Generation and Consumption by Sector

	Unit	2003	2004	2005	2006	2007	Annual Increase Rate%
Total capacity of power equipment	GW	4.2221	4.2661	4.4281	4.5691	4.6001	2%
Annual generated power	GWh	8777.41	11928.94	13807.35	12735.65	12949.7	10%
Annual electricity consumption	GWh	9773.36	10591.25	10315.41	10993.89	12594.44	7%
Industry	GWh	8054.95	8834.12	8501.96	9025.36	10482.05	7%
Agriculture	GWh	54.99	48.44	118.96	137.76	145.23	27%
Households	GWh	1017.95	1034.02	1042.22	1095.85	1188.21	4%
Others	GWh	645.47	674.67	652.27	734.92	778.95	5%

Note: The total capacity of power equipment includes all of power plants larger than 6000 kW and 3 small hydropower stations (Long Yun, Long Cheng and Song Bai).

The amount of total coal consumption is 14.736 million ton, 86% of which are consumed by electricity, chemical, building materials and metallurgy industry. The amount of self producing coal is 3.35 million ton (2.01 million ton coal are produced by Shu Lan Mining Group and 1.34 million ton coal are local production), accounting for 22.7% of total demand, and the rest depends on coal from other provinces.

3 Model Method

3.1 Methodology Framework

In order to present energy and emission scenarios for Jilin province, a modelling

framework for scenario analysis is adopted. The IPAC-AIM/Technology model will be used for the analysis. The IPAC-AIM/technology model has been used for the national energy and emission scenario analysis and several regional scenario analyses including Beijing, Guang Dong, and Hong Kong. This study will adopt a similar framework as previous studies.

The time span of this study is 2005 to 2030 to relate to the local energy planning period and issues with the climate change plan. 2005 will be the base year.

CO₂ is the main greenhouse gas (GHG) covered.

3.2 Models

The IPAC-AIM/Technology model is a single-region model for China, developed based on the AIM/end-use model (AIM Project Team 1996; Hu, Jiang, and Liu, 1996; Hu and Jiang 2001; Jiang and others 1998). This model includes three modules (energy-service demand projection, energy-efficiency estimation, and technology selection) (see Figure 7). Demand is divided among the industrial, agricultural, service, residential, and transportation sectors, which are further divided into subsectors (see Table 3). On both the demand and supply sides, more than 400 technologies are considered, including existing as well as technologies that may be used in the future (see Table 4). The model searches for the least-cost technology mix to meet the given energy-service demand. The most up-to-date information on these technologies was collected from a large number of published sources, as well as by consulting with experts directly. Key factors could be analyzed by the model and linkage with policies is given in Table 5. The policy options could be simulated by the model to see the effects.

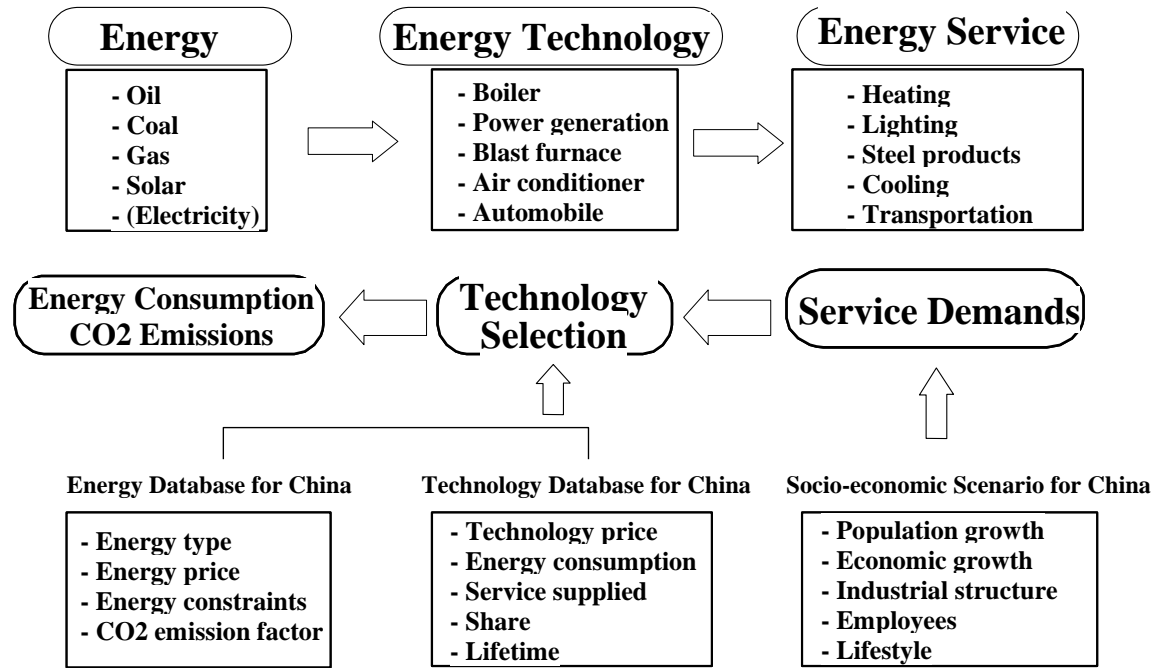


Figure 7: Structure of IPAC-AIM/technology Model (Jiang et al, 1998)

Table 3: Classification of Energy End-Use Sectors and Subsectors

Sector	Subsectors
Agriculture	Irrigation, farming works, agricultural-products processing, fishery, animal husbandry
Industry	Iron and steel, nonferrous metals, building materials, chemicals, petrochemicals, paper-making, textiles
Household	Urban and rural: Space heating, cooling, lighting, cooking and hot water, household electric appliance
Service	Space heating, cooling, lighting, cooking and hot water, electric appliance
Transportation	Passenger and freight: Railway, highway, waterway, airway Freight: Railway, highway, waterway, airway

Table 4: Selected Technologies Considered in the IPAC-AIM/Technology Model

Classification	Technologies
Iron and Steel	Coke ovens; sintering machines; blast, open hearth, basic oxygen, and AC and DC electric arc furnaces; ingot-casting machines; continuous-casting machines; continuous-casting machines with rolling machines; steel-rolling machines; continuous steel-rolling machines; dry and wet coke-quenching equipment; electric power generated with residue pressure on top of blast furnace; coke-oven gas, open-hearth gas, and basic oxygen-furnace gas recovery; cogeneration equipment
Nonferrous Metal	Aluminum production with sintering process, aluminum production with combination process, aluminum with bayer, electrolytic aluminum with upper-insert cell, electrolytic aluminum with side-insert cell, crude copper production with flash furnace, crude copper production with electric furnace, blast furnaces, reverberator furnaces, lead smelting-sintering in blast furnace, lead smelting with closed blast furnace, zinc smelting with wet method, zinc smelting with vertical pot method
Building Materials	Cement: Mechanized-shaft, ordinary-shaft, wet-process, lepol kiln, ling-dry, rotary with pro-heater, dry-process rotary with precalciner, Hoffman, and tunnel kilns; self-owned electric-power generators; electric power generators with residue heat; bricks and tiles Lime: Ordinary-shaft kilns, mechanized-shaft kilns Glass: Floating, vertical, and Colburn processes; smelters
Chemical Industry	Synthetic ammonia: Converters, gasification furnaces, gas-making furnaces, synthetic columns; shifting of sulfur-removing equipment Caustic soda production: Electronic cells with graphite process, two-stage effects evaporators, multistage effects evaporators, rectification equipment, ion-membrane method Calcium carbide production: Limestone calciners, closed carbide furnaces, open carbide furnaces, residue heat– recovery equipment Soda ash: Ammonia and saltwater preparation, limestone calcining, distillation columns, filters Fertilizer: Equipment for production of organic products, residue heat utilization
Petrochemical Industry	Atmospheric and vacuum distillation, rectification, catalyzing and cracking, cracking with hydrogen adding, delayed-coking, and light-carbon cracking facilities; sequential separators; naphtha, diesel, and de-propane crackers; de-ethane separators; crackers; facilities of residue heat utilization from ethylene
Paper-making	Cookers; distillation, washing, and bleaching facilities; evaporators, crushers; water-seperator, finishing, residue heat utilization, and black-liquor recovery facilities, co-generators; and back-pressure electric power and condensing electric power generators

Table 4: Selected Technologies Considered in the IPAC-AIM/Technology Model (Continued 1)

Classification	Technologies
Textile	Cotton-weaving process, chemical fiber process, wool-weaving and textile process, silk process, printing and dyeing process, garment-making, air conditioners, lighting, space heating
Machinery	Ingot process: Cupolas, electric arc furnaces, fans Forging process: Coal-fired, gas-fired, and oil-fired preheaters; steam- and electric-hydraulic hammers; pressing machines Heat-processing: coal-fired, oil-fired, gas-fired, and electric heat-processing furnaces Cutting process: Ordinary cutting, high-speed cutting
Irrigation	Diesel engines, electric induct motors
Farming Works	Tractors, other agricultural machines
Agricultural Products Process	Diesel engines, electric induct motors, processing machines, coal-fired facilities
Fishery	Diesel engines, electric induct motors
Animal Husbandry	Diesel engines, electric induct motors, other machines
Space heating in Resident	Heat-supplying boilers in thermal power plants, district-heating plant boilers, dispersed boilers, small coal-fired stoves, electric heaters, brick beds linked with stoves (Chinese Kang), energy-saving building
Cooling in Resident	Air conditioners, high-efficiency air conditioners, electric fans
Lighting in Resident	Incandescent, fluorescent, and kerosene lamps
Cooking and Hot Water in Resident	Gas burners; bulk coal-fired, briquette-fired, methane-fired, cow dung-fired, kerosene, and firewood-fired stoves; electric cookers
Household Electrical Appliances	Televisions, washing machines, refrigerators, other appliances
Other Electric Equipment	Photocopiers, computers, elevator, other appliances
Space Heating in Service Sector	Heat-supplying boilers in thermal power plants, boilers in district heating plants, dispersed boilers, electric heaters
Cooling	Central air conditioning, air conditioners, electric fans
Lighting	Incandescent, fluorescent lamps
Cooking and Hot Water	Gas ranges, electric cookers, hot-water pipelines, coal-fired stoves

Table 4: Selected Technologies Considered in the IPAC-AIM/Technology Model (Continued 2)

Classification	Technologies
Passenger and Freight Transport	Railways: Steam, internal combustion engine, and electric locomotives Highways: Public diesel, public gasoline, and private vehicles; large diesel freight trucks, large gasoline vehicles, small freight trucks Waterways: Ocean-going, coastal, and inland ships Aviation: Freight and passenger planes
Common Technologies	Electric motors; frequency-adjustable electric motors; coal-fired, high-efficiency coal-fired, natural gas-fired, and oil-fired boilers
Power Generation	Low-parameter coal-fired, high-pressure critical coal-fired, super-critical coal-fired, natural gas-fired, oil-fired, and nuclear generators; PFBC, Integrated gasification combined cycle, Natural gas combined cycle; wind turbines; hydropower; solar power generation; biomass and landfill power generation

Source: Jiang et al, 1998

Table 5: Factors Influenced by Key Driving Forces

Driving Force	Sector	Factors	Policies to Promote the Change
Social-efficiency Change	Industry	Value-added change by subsectors within the sector (as service demand of some subsectors, including machinery, other chemical, other mining, and other industry, could be changed based on economic mix change) Products structure change within one sector (as service demand in most industrial sectors)	Various policies relative to value added, such as price policy, national plan for key industry, promotion of well-functioning markets, market-oriented policies, national development policies
	Residential and commercial	Change in energy activity within the sector (use of heating, cooling, more efficient electric appliances)	Public education, price policies
	Transport	Change of transport mode (more public transport, nonmobility(walking and bicycle use) traffic volume (as result of decline in use of private cars)	Transport development policies, public education
Technology Progress	All sectors	Efficiency progress for technology (improvement in	Promotion of technology R&D, market- oriented policies,

		unit energy use); changes in technology mix (more advanced technologies); changes in fuel mix (more renewable energy and nuclear)	international collaboration, environmental regulation, energy-industry policies, import and export policies, tax system
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Source: Jiang et al, 2006

4 Definitions of Scenario

- Baseline scenario: the baseline is sustainable development under the current economic development pattern. Do not take any new policy into account besides policies issued already.
- Policy scenario: the scenario is designed to analyze the effect of energy saving, renewable energy promotion and pollution reduction under great efforts (including policy, investment and energy expenditure). The main factors are economic structure optimization, the decrease of the proportion of added value of highly energy- consuming industries in heavy industry, and the promulgation of energy saving technology. Industry: by 2020, the main highly energy- consuming industries will catch up or precede the advanced country level, and the industry will generally realize effective and cleaner production. Architecture: new buildings will reach the energy saving standard, and the consumption of the public is mainly low energy- consuming commodities (including purchasing, electric equipment using, renewable energy using and life style). The renewable energy will be made the best use of, including wind power, solar thermal utilization, photovoltaic cell, biomass energy power generation and liquefaction, small scale hydropower, garbage power. Besides, the carbon mitigation technology should be taking into account since Jilin is one of the richest provinces in China.
- Low carbon scenario: the scenario takes all the polices related to further green house gas reduction into account, to analysis the potential of low carbon emission in the pilot project, especially the potential of CCS.

5 Scenario Parameter

5.1 Main Model Parameters

The research mainly uses the model to process quantitative analysis, in order to better understand the political implication. The main parameters can be seen in Table

6.

The scenario of population growth comes from the population planning mentioned above and other related research. Since the population growth is more rapid than that in the planning, some adjustment is made to the population scenario based on the planning (see Table 6). The population policy is not involved in the energy development and low carbon scenario policy, thus the analysis does not cover different population scenario.

Table 6: Population Growth

	2005	2010	2020	2030
Total, million	4.304	4.6	4.82	5.05
Urban	2.1	2.76	3.2294	3.737
Rural	2.2	1.84	1.5906	1.313
Urbanization Rate, %	48.8%	60%	67%	74%
City Household, million	0.72	0.99	1.20	1.44
Rural Household, million	0.69	0.59	0.53	0.45
Urban HH Member	2.9	2.8	2.7	2.6
Rural HH Member	3.2	3.1	3.0	2.9

The data of GDP growth are based on the development planning and related research see Table 7.

Table 7: Economic Growth Parameter

	2005-2010	2010-2020	2020-2030
GDP Growth Rate	15%	10%	7%
	2005	2010	2020
GDP, Billion Yuan	80.5	162	420
Mix, %			
Primary	13.3	8	6
Secondary	46.6	54	53
Tertiary	40.1	38	41

Table 8: The Main Product Output, Baseline Scenario

	2000	2005	2010	2020	2030	
Steel	10 ³ ton	1.2	1,280	1,500	2,500	3,000
Concrete	10 ³ ton	1,220	2,910	9,000	12,000	15,000
Tile	0.1 billion		2	5	9	10
Ethylene	10 ³ ton	430	510	1,800	2,300	2,800
Vitriol	10 ³ ton	84	139	180	200	200
Fuel ethanol	10 ³ ton	0	350	600	800	800
Automobile	10 ³ ton	40	62.7	400	800	1,000
Paper	10 ³ ton	0	0	340	800	1,000
Coal	10 ³ ton	0	2908.3	4300	6000	6000

Table 9: The Main Product Output, Policy Scenario

		2000	2005	2010	2020	2030
Steel and Iron	10 ³ ton	0	1280	1500	2500	3000
Concrete	10 ³ ton	1220	2910	9000	10000	10000
Tile	0.1 billion	0	2	5	9	8
Ethylene	10 ³ ton	430	510	1800	2300	2800
Vitriol	10 ³ ton	80	140	180	200	200
Fuel Ethanol	10 ³ ton	0	350	600	800	1600
Automobile	10 ³ ton	40	60	400	800	1000
Paper	10 ³ ton	0	0	340	800	1000
Coal	10 ³ ton	0	2910	4300	4300	4000

Indexes related to energy demand of different sectors can be seen in Table 10.

Table 10: Urban Resident Development Index

	2005	2010	2020	2030
Population	2.10	2.76	3.23	4.45
HH	724259	985714	1196074	1437308
Area, m ²	34	41	43	44
Member per HH	2.9	2.8	2.7	3.1
Index of Service, 2005=1				
Cooking	1	1.36	1.65	1.98
Electric Cooking	1	1.34	1.91	2.66
Hot Water	1	1.51	2.42	3.53
Space Heating	1	1.44	1.84	2.29
Air Conditioner	1	1.81	2.84	5.75
Fan	1	1.41	1.71	2.05
Lighting: C	1	1.42	1.80	2.08
Lighting: F	1	2.55	3.34	4.47
Refrigerator	1	1.74	2.58	3.32
Color TV	1	1.91	2.76	3.72
Washing Machine	1	1.91	3.21	5.32
Other Electric Appliance	1	1.36	1.65	1.98

Table 11: Rural Resident Development Index

		2005	2010	2020	2030
Population	million	2.20	1.84	1.59	1.31
HH		688640	593548	530200	452759
Area	m ² /HH	99	110	120	130
Member per HH		3.2	3.1	3.0	2.9
Index of Service, 2005=1					
Kitchen Work		1	0.93	0.90	0.82
Electric Power for Kitchen Work		1	0.85	1.51	1.93
Hot Water		1	0.93	1.16	1.13
Heating		1	0.94	0.91	0.84
Air-conditioning		1	1.39	2.87	4.65
Electric Fan		1	0.94	0.95	0.94
Lighting: Incandesce Lamp		1	0.79	0.64	0.55
Lighting: Fluorescent Lamp		1	1.09	1.32	1.45
Refrigerator		1	1.43	2.49	2.55
Television		1	1.16	0.49	1.42
Washing Machine		1	1.12	1.66	2.55
Others		1	1.34	1.71	1.86

Table 12: Building and Transportation Index

		2005	2020		2030		Policy	Complexity of policy	Suggested implement time
			Baseline scenario	policy scenario	Baseline scenario	policy scenario			
Energy- saving Building		3%	30%	50%	40%	70%	Energy- saving standard; provide subsidy to energy- saving buildings	Easy	Now. Besides, the most advanced energy- saving building should be encouraged.
Energy- saving Refrigerator		15%	70%	100%	85%	100%	Energy- saving standard, and continuously raise the 5 th energy efficiency standard, e.g. Top-Runner policy manner used in Japan	Easy. New technology has already been developed with little cost increase.	Now. Besides, the minimum energy efficiency standard should be raised as soon as possible.
Energy- saving Air-conditioning		12%	50%	95%	75%	100%	The same as above	The same as above	The same as above
Energy- saving Washing Machine		16%		100%		100%	The same as above	The same as above	The same as above

Table 12: Building and Transportation Index (continued 1)

		2005	2020		2030		Policy	Complexity of policy	Suggested implement time
			Baseline scenario	policy scenario	Baseline scenario	policy scenario			
Energy-saving Apparatus	Computer, lift, duplicator	10%	45%	85%	65%	95%	Energy- saving standard	The same as above	The same as above
Solar Water Heater	Turn to new water heater		5% of total space	30%	10%	50%	Set as one of the criteria of energy-saving building, symbolic subsidy	Medium Relatively easy Heat pipe technology is mature, and substitutes more than 85% gas water heater	Now Now
Indoor Energy Uses			Reduce 110 kgce each household	Reduce 190 kgce each household	Reduce 120 kgce each household	Reduce 210 kgce each household	Public education; Less air conditioning, more electrical fan; Turn off the standby power; Multi level lighting 30 L- shower Energy- saving domestic appliance Control the indoor temperature and dress appropriately	Easy	Now

Table 12: Building and Transportation Index (continued 2)

		2005	2020		2030		Policy	Complexity of policy	Suggested implement time
			Baseline scenario	policy scenario	Baseline scenario	policy scenario			
Rural Resident	LPG/DME popularization rate	14%	20%	40%	35%	80%	Increase the supply of LPG and DME to the rural area	Easy	Now
	popularization rate of large-scale biomass gasification for gas supply	0	6%	20%	6%	45%	New countryside construction	Relatively hard, and government support is needed	Now
	popularization rate of solar heating	0	2%	10%	8%	80%	Popularize the solar water heater of low cost, subsidy (combined with new countryside construction)	Easy	Now
Low Energy-consumption Vehicle		16%	55%	85%	60%	92%	Improve the fuel economy standard (less than 5 L per 100 km)	Relatively easy, promulgate the roadmap	Now
							Public education (Buy energy-saving vehicle)	Easy	2008

							Provide subsidy to compact vehicle with low energy consumption Make the public facilities more preferential to compact vehicle with low energy consumption	Relatively easy	2008
Public Transportation		20%	35%	60%	40%	65%	Public transport priority resolutely (financial input, municipal construction, public consensus, bus) Rail transit construction (increase the input greatly, build perfect rail transit system in every city with population large than 2 million)	Relatively easy, depend on social investment and financial input	Now
Non-motorized Vehicle		45%	30%	45%	32%	50%	Turn around the present transportation policy designed for vehicles, and set a transportation system more preferential to travel on foot and by bicycle.	Relatively hard, the consciousness should be transformed	Make effort from now
Transportation Demand Reduction				9%		13%	Tele-conference, school bus, productions localization		

Table 13: Technology Index

Technology	Efficiency	Share in 2030		Note
		BaU	Policy	
Advanced Coke Oven	11,900 Mcal/ ton coke, with gas production of 1,340 Mcal	58%	50%	Fully localization
New generation Coke Oven	10,300 Mcal/ ton coke, with gas production of 1,420Mcal	17%	47%	
Dry Quenching	2.4 Mcal/ ton J Recovery	80%	100%	Localization, with promising prospect of market potential
Sintering Furnace of International Advanced Level	390 Mcal/ ton sinter lump, saving 42% of energy	45%	85%	Needed to be localization
Blast Furnace of International Advanced Level	3750 Mcal/ ton hot metal, saving 21% of energy	40%	65%	
Blast Gas Recovery /TRT	Heat and electricity recovery 0.7 Mcal/ ton hot metal	44%	70%	
Continuous Casting and Rolling	Saving 86% of energy	90%	98%	
Large-scale Converter (Oxygen Enrichment, Negative Pressure)	170 Mcal/ ton molten steel, saving 23% of energy	34%	30%	
Advanced Converter (Oxygen Enrichment, Negative Pressure, Gas Recovery)	218 Mcal/ tonmolten steel, recovering 286Mcal/ ton molten steel	37%	70%	
Hot Transportation and Hot Charging	Saving 44% of energy	70%	95%	
New Dry Cement + Waste Heat Recovery	102 kgce/ton clinker	75%	100%	

Table13: Technology Index (continued 1)

Technology	Efficiency	Share in 2030		Note
		BaU	Policy	
Advanced Copper Melting Furnace	0.5tce/ton	75%	100%	
Alumina Energy Saving Technique	Saving 8% of energy	85%	100%	
New Lead and Zinc Smelting Technique(SKS)	0.379 tce/ ton, saving 21% of energy	80%	100%	
Large Scale Synthetic Ammonia	8,500 Mcal/ ton, with the most advanced level of 6,926 Mcal/ ton	70%	96%	
Ionic Membrane Caustic Soda	3,744 Mcal/ ton, saving 34% of energy	80%	98%	
Ethylene Raw Material and High-Efficiency Heat Match	6,517 Mcal/ ton, saving 38% of energy	66%	95%	
Rapid Displacement Heating (RDH), Continuous Cooking		80%	100%	
Energy-saving Building	Saving 50% of the energy	20%	30%	
	Saving 65% of the energy	16%	25%	
	Saving 75% of the energy	4%	15%	
Energy-efficient Refrigerator	Saving 65% of the energy	85%	100%	
AC Frequency Conversion Air Conditioner	Saving 30% of the energy	65%	20%	
DC Inverter Air Conditioner	Saving 50% of the energy	15%	60%	
Super Air Conditioning	Saving 75% of the energy	0%	20%	COP>5.5
Compact Energy-saving Lamp	Saving 80% of the energy	80%	95%	
Energy-saving Washing Machine	Saving 30% of the energy	80%	100%	

Table 13: Technology Index (continued 2)

Technology	Efficiency	Share in 2030		Note
		BaU	Policy	
Energy-saving Electrical	Saving 40% of the energy	65%	95%	
Solar Heater		9%	15%	
Indoor Energy Consumption		each family can reduce 120 kgce energy consumption	each family can reduce 210 kgce energy consumption	
LPG/ gas Stove	The efficiency is 51%			
Energy-saving LPG/ gas Stove	The efficiency is 58%			
Low Energy Consumption Vehicle	5.4 liter/ hundred kilometer	56%	45%	
Hybrid Power Vehicle	4.3 liter/ hundred kilometer	20%	35%	
Ultra-high Fuel Economu Vehicle	Less than 3 liter/ hundred kilometer	0%	10%	
Bus	Energy consumption per kilometer is 1/6 of that of cars			
Metro	Energy consumption per kilometer is 1/22 of that of cars		Accounting for 30% of the vehicle out-driving in big cities	
Electric Bicycle	Electricity consumption per kilometer is 1.2 kWh			
Supercritical/ Ultra Supercritical Power Generation	The efficiency is 42%		35%	
IGCC/ Poly-Production	The efficiency is 45%, and will be 54% in 2030		3%	

5.2 Main Industry Trades Development

5.2.1 Chemical Industry

Ammonia

The competitive technologies chosen in 2030 are mainly the large-scale production technologies. From 2010, natural gas based large-scale ammonia, coal-based large-scale ammonia and heavy oil-based large-scale ammonia will become the three main ammonia production techniques. The disadvantages of mid- and small-scale ammonia will become more and more obvious. It is estimated that in 2020, this sector will reach the current international advanced level, with the comprehensive energy consumption reaching 1100kgce/t, 30% lower than the current energy consumption level. In 2030, this sector will catch up with the efficiency of developed countries and reach the international advanced level at that time. The comprehensive energy consumption will reach 1000kgce/t, another 10% lower than 2020.

Caustic soda and sodium carbonate

In 2005, the share of production of ion-exchange membrane caustic soda was only 36.7%; however, in Japan and America, their caustic soda is mostly produced by ion-exchange membrane. China now has grasped the design and production capacity of large-scale ion-exchange membrane equipment; the current production line technology and equipment has also basically reached the international advanced level. The future task is to further increase the share of large-scale ion-exchange membrane caustic soda. In 2020, China will mainly build ion-exchange membrane caustic soda projects larger than 200,000 tons per year. The share of ion-exchange membrane caustic soda should reach 50% in 2020 and 65% in 2030.

Besides, through improving design and equipment production capacity and developing large-scale natural cycle high current density cell¹ as well as ion-exchange membrane - oxygen cathode electrolysis technology², the energy consumption of ion-exchange membrane caustic soda could be further decreased. It is estimated that in 2020, the comprehensive energy consumption of ion-exchange membrane caustic soda can reach 1010 kgce/t, 10% lower than the current value; in 2030, it can reach 980 kgce/t. Comprehensive energy consumption of ammonia alkali and soda can reach respectively 410kgce/t and 270kgce/t in 2020; and 380kgce/t and 250kgce/t in 2030.

Caustic soda sector will mainly develop ion-exchange membrane production techniques. The share of caustic soda produced by ion-exchange membrane will reach

¹ This technology can save electricity 20-30kWh/t alkali.

² This technology can save electricity 400kWh/t alkali.

to 55% in 2020 and 73% in 2030. Meanwhile, the average scale of ion-exchange membrane production line will be increased, from 200,000 t/a in 2020 to 300,000 t/a in 2030, 50% larger than the average scale in BaU.

Ethylene

The raw materials to produce ethylene will be stabilized and lightened. The development of ethylene sector in China should combine the oil and the chemical sector. Through the optimization of raw materials from the refinery plant and the proper import of light raw materials, the supply of raw materials to produce ethylene will be stabilized and lightened. It is needed to first guarantee the oil supply for petroleum and chemical sector. Along with the rapid development of Chinese economy, the domestic crude oil supply may not be able to meet the amount of domestic demand. The first solution is to better utilize the domestic and imported oil resources, and further optimize the raw materials for ethylene pyrolysis to ensure the quality and quantity of raw materials for ethylene production; the second solution is to limit the burning of oil and decrease the export of domestic crude oil. From the model's quantitative analysis results, share of naphtha in the raw materials of ethylene production will reach 70% in 2030. Currently, the share of production by large-scale ethylene production equipments is 66.7%. In the future, through building new large-scale equipments and further phasing out small and medium equipments, the share of large equipments in 2020 will reach 75% in 2020 and 80% in 2030. Through all the measures mentioned above, it is estimated that the comprehensive energy consumption of ethylene production will reach 520kgoe/t in 2020; the technology level will be comparable to the international advanced level at that time. In 2030, the comprehensive energy consumption will reach 490kgoe/t, top of the world technology level.

Table 14: Technology Parameters in Chemical Sector

Technology	Indicator	Level of Technology Penetration	
		2020	2030
Raw Material Improvement in Ethylene Production and the Efficient Heat Exchange Tower	6,517Mcal/t, saving 38% of energy	66%	95%
Large-Scale Ammonia Production Set	8,500Mcal/t, the most advanced one can reach 6,926Mcal/t	70%	96%
Sodium Carbonate – Advanced Ammonia Alkali and Method Soda	360 kgce/t	50%	54%
Sodium Carbonate – Advanced Soda Method	230 kgce/t	36%	46%
Caustic Soda – Advanced Ion-Exchange Membrane Method	950kgce/t	55%	75%
Calcium Carbide – Advanced Closed Furnace	1,300kgce/t	90%	100%

5.2.2 Cement Industry

In the coming 30 years, the technology level of China's cement sector will be increased remarkably. The current new-built cement production line has become the global leader. From now on, the advanced dry preheating calcining kiln will become the key technology in new built cement plant. This will make the type of advanced kiln become the dominant technology in Chinese cement plants after 2020.

Besides, some other technologies which can be applied in new dry preheating calcining kiln and promote the overall energy efficiency level are: (1) utilization of combustible waste in cement sector: share of secondary fuel in dry preheating calcining kiln will reach 8% in 2010, 15% in 2020 and 25% in 2030; (2) mid- and low-temperature waste heat recovery technology: it will be generally applied in 2030; the generation capacity per ton of clinker could reach 32~48 kWh; share of dry preheating calcining kiln using mid- and low-temperature waste heat recovery technology will reach 40% in 2010, 70% in 2020 and 100% in 2030.

Through all these comprehensive measures, the comprehensive energy consumption in China's new dry preheating calcining kiln will reach 96kgce/t, 12% lower than the current level, and reaching the international advanced level at that time. This energy efficiency level will be comparable to the level of the most advanced

production line in the world right now. In 2030, the comprehensive energy consumption per ton of cement will reach 90kgce, another 6% lower than the 2020 level, reaching the top of the world.

Table 15: Main Energy Saving Technologies' Parameters in Cement Sector

Technology	Indicator	Level of Technology Penetration	
		2020	2030
New Dry Preheating Calcining Production Line	104kgce/t clinker	90	100
Waste Heat Recovery	34kWh/t clinker	80	100
Waste Residue Blended with Clinker	Nearly doesn't consume energy	20	30

5.2.3 Steel Making Industry

The iron and steel sector in China has already started to have obvious improvement in energy efficiency level, under the requirements of domestic energy-saving and emission reduction actions. Considering the lifetime and retrofits period of technology, the technologies in iron and steel sector will continue the current modernization, scaling up and high efficiency path. The newly built iron and steel plants will adopt advanced energy saving technologies, making the energy efficiency of Chinese iron and steel sector topped the world around 2030.

In the low carbon scenarios, the deployment rate of advanced high efficiency technologies will have an obvious increase. Till 2030, all the current existing important energy saving technologies will be fully applied. From now on, through building new plants and reconstructing the existing plants, the main technologies during the iron and steel production process will all become world leader. The main technologies and equipments, including advanced coke ovens (11,900 Mcal/ton coke, producing 1,340 Mcal gas), new generation of coke ovens (10,300 Mcal/ton coke, producing 1,420 Mcal gas), international advanced sintering oven (390 Mcal/ton sintered block, saving 42% of energy), advanced blast furnace (3,750 Mcal/ton molten iron), big convertor(oxygen-rich, negative pressure) and advanced convertor (oxygen-rich, negative pressure, gas recovery), big advanced electric arc furnaces, secondary refining, advanced technologies in rolling, hot metal charging and hot delivery (saving 44% of energy), will be universal. Meanwhile, energy saving technologies such as coke dry quenching and TRT will be popularized; and through recovery of coke oven gas, blast furnace gas and convertor gas, plants will use CCPP to generate power and heat. In 2030, the overall energy efficiency and technology level will get close to or reach the international advanced level. After 2030, the share of electric arc furnaces will get a sharp increase, resulting in an obvious decrease in total energy consumption per ton of steel produced (see Table 16).

Table 16: Technology Parameters in Iron and Steel Sector

Technology	Indicator	Level of Technology Penetration		
		2005	2020	2030
New Blast Furnace		68%	80%	100%
TRT		34%	100%	100%
BFG Recovery			70%	90%
Big and Advanced Coke Oven	Output rate is 82%; producing coke oven gas of 760Mcal	36%	55%	80%
Coke Oven Gas Recovery		67%	100%	100%
250 kg PCI into Blast Furnace	Replacing coke			
Coke Dry Quenching	Heat recovered from coke reaches 190Mcal		60%	80%
Direct Current/Alternating current arc Furnace above 120t		34%	75%	95%
Recover of Converter Gas	Negative energy converter steel making, -16 kgce/t steel	16%	78%	95%
Continuous Casting and Rolling	Saving 75% of energy	88%	95%	98%
Hot metal Charging and Hot Delivery	Saving 47% of energy	37%	85%	95%
New Heating Furnace	Saving 30% of energy	25%	70%	90%

5.2.4 Power Generation

Electric power generation techniques of SC and USC. In recent years, the SC and USC power generations develop very fast. The localization process of SC sets has completed, and the localization rate of USC is more than 80% (Kejun Jiang, 2007). Nowadays, 60% newly constructed SC and USC sets are in China. Till the end of 2007, there are more than a hundred of SC sets and more than ten USC sets in China (Kejun Jiang, 2008). Until now, the total investment has reached 3900yuan/kW (IPAC electric database). According to the policies of NDRC, the basic requirements of newly constructed coal-fired power plants are SC and USC (NDRC 2007). This indicates the fact that the SC and USC techniques have been entering the commercialization process.

IGCC/ Co-Generation technique. Recently, the development of IGCC sets has entered the expansion process. The demonstration project of 300~400MW IGCC set (State Grid Yantai) funded in 1999, has been arranged. The first phase of demonstration 250MW IGCC (CHINA HUANENG GreenGen) estimates operation at 2009, which adopts the advanced gasification technology based on pulverized coal: CO₂ separation, hydrogen production, and the separation of Molten Carbonate Fuel Cell experimental system. The second phase of IGCC with 300~400MW estimates operation at 2015, with the advanced gasification technology based on pulverized coal: 100MW CO₂ separation, hydrogen production, and hydrogen power generation demonstration system. About 3 to 5 IGCC with 300-400 MW are arranged by the corporations of China Da Tang and China Power investment. According to the feasibility analysis of several IGCC projects in China, we can find out the construction cost of IGCC sets, about 7000yuan/kW to 8000yuan/kW. We estimate that the cost will reduce to 6800yuan/kW when the technology is mature.

Power generation by regenerative energy. 1) Solar PV Technology. Besides applied for remote areas and special fields (communication, navigation, and transportation), the demonstration project of electric generation using Solar PV on housetop has been constructed. There are more than 10 enterprises (including manufacturers and package factories), and the output capacity is more than 100MW. 2) Wind Power generation: The industry develops very fast, and unit capacity has increased from 600kW to 5000kW. Technology of 2000kW sets have matured, which is widely applied for wind power generation in land. The 2000kW sets can be manufactured in China, and the 1500kW sets have the exclusively self-retained technology. Therefore the progress of local production reduces the cost, which is 10%-20% lower than the import price. The electric generation cost is reduced to 6000 yuan/kW because of the large scale production.

Table 17: Technology Parameters of Electric Industry

Electric Generation Technologies	Proportion of Market %	
	2020	2030
SC and USC in All Coal-fired Power Plant	55	52
Proportion of Nuclear Power	12	20
Proportion of Regenerative Energy (Except for the Hydro Power)	1.2	10

5.2.5 Other Industrial Sector

For other industrial sectors, according to the energy consuming technologies, they will mainly use the general energy saving technologies, such as electric machinery, lighting, boiler, kiln and etc. According to related materials (NDRC, 2004), the settings of related parameters are shown in Table 18.

Table 18: Technological Parameters of Other Industrial Sectors

Technology	Indicator	Share of Technology Penetration	
		2020	2030
Efficient Energy Saving variable Frequency Motor	Saving 30%-45% of electricity	50%	80%
Efficient Coal-fired Boiler	Efficiency can reach 85%-90%	60%	85%
Efficient Industrial Lighting	Saving 45% of electricity	70%	95%
Combined Heat and Power			
Energy Saving from Management Side	Saving 45% of energy		

- The unit consumption of high energy- consumption production shows the downtrend

Based on the analysis on the technology potential of different industries, the unit consumption of high energy-consumption product can be calculated from the model (see Table 19).

Table 19: Unit Consumption of High Energy-Consumption Product under Policy Scenario

Sector	Unit	2005	2020	2030	2050
Steel and Iron	kgce/t	760	650	564	525
Cement	kgce/t	132	101	86	81
Synthetic Ammonia	kgce/t	1,645	1,328	1,189	1,170
Ethylene	kgce/t	1,092	796	713	705
Soda	kgce/t	340	310	290	280
Copper	kgce/t	1,273	1,063	931	920
Aluminum	kWh/t	15,000	12,870	12,170	12,000
Paper Making	kgce/t	1,047	840	761	740
Thermal Power	Gce/kWh	350	305	290	271

6 Energy and Emission Scenario

Based on the parameter setting above, we use IPAC-AIM/ technology model process the scenario analysis on the energy demand and CO₂ emission of Jilin City.

The primary result of the model can be seen from Table 20 to Table 25.

Table 20: Primary Energy Consumption, Baseline Scenario, 10,000 T Standard Coal

	Nature					Total
	Coal	Coke	Petroleum	Gas	Electricity	
2007	915.7	73.2	540.4	2.8	30.8	1,563.0
2010	1,327.8	131.8	864.7	8.9	58.6	2,391.8
2020	1,858.9	170.1	1,037.7	38.4	111.3	3,216.3
2030	2,323.6	192.2	1,141.4	88.4	189.2	3,934.8

Table 21: Final Energy Consumption, Baseline Scenario, 10,000 Ton Standard Coal

	Natural			Thermal		Electricity	Total
	Coal	Coke	Petroleum	Gas	Power		
2007	257	90	526	3	257	155	1,289
2010	359	141	755	6	323	212	1,797
2020	538	183	992	20	472	387	2,592
2030	547	185	1,343	38	687	677	3,476

Table 22: Primary Energy Consumption, Policy Scenario, 10,000 Ton Standard Coal

	Nature					Total
	Coal	Coke	Petroleum	Gas	Electricity	
2007	915.7	73.2	540.4	2.8	30.8	1,563.0
2010	1,282.0	87.9	864.7	5.9	55.5	2,295.9
2020	1,564.0	96.7	1,037.7	14.1	105.4	2,817.9
2030	1,798.6	106.3	1,079.2	29.6	337.3	3,351.0

Table 23: Final Energy Consumption, Policy Scenario, 10,000 Ton Standard Coal

	Natural			Thermal		Electricity	Total
	Coal	Coke	Petroleum	Gas	Power		
2007	259.1	90.2	527.1	2.8	257.3	154.8	1,291.3
2010	343.2	136.2	721.7	6.5	305.8	202.7	1,716.1
2020	468.2	166.2	902.7	20.3	432.8	355.6	2,345.8
2030	432.7	161.2	1,095.4	38.3	602.9	552.3	2,882.8

Table 24: Final Energy Consumption by Sector, Baseline Scenario, 10,000 Ton Standard Coal

2007				Natural	Thermal		
	Coal	Coke	Petroleum	Gas	Power	Electricity	Total
Agriculture	24.2	0.0	2.3	0.0	0.0	1.8	28.3
Industry	120.3	90.2	455.2	1.7	170.5	128.8	966.7
Service Industry	62.8	0.0	14.1	0.0	41.0	9.3	127.2
Transportation	0.0	0.0	49.8	0.0	0.0	0.3	50.1
Urban household	12.0	0.0	4.6	1.1	44.3	12.0	74.0
Rural household	39.8	0.0	1.1	0.0	1.5	2.6	45.0
Total	259.1	90.2	527.1	2.8	257.3	154.8	1,291.3
2010							
	Coal	Coke	Petroleum	Natural	Thermal		
	Coal	Coke	Petroleum	Gas	Power	Electricity	Total
Agriculture	31.5	0.0	4.4	0.0	0.0	3.2	39.1
Industry	173.2	140.7	610.0	3.6	211.4	171.3	1,310.2
Service Industry	87.9	0.0	21.2	1.1	57.4	16.7	184.3
Transportation	0.0	0.0	109.6	0.0	0.0	0.5	110.0
Urban household	14.4	0.0	8.3	1.7	54.5	16.8	95.6
Rural household	51.7	0.0	2.0	0.0	0.0	3.6	57.4
Total	358.8	140.7	755.3	6.3	323.3	212.2	1,796.6
2020							
	Coal	Coke	Petroleum	Natural	Thermal		
	Coal	Coke	Petroleum	Gas	Power	Electricity	Total
Agriculture	36.5	0.0	5.7	0.0	0.0	5.8	48.0
Industry	291.0	182.9	768.6	8.2	306.6	306.6	1863.9
Service Industry	126.6	0.0	27.5	8.8	80.4	33.1	276.4
Transportation	0.0	0.0	175.3	0.0	0.0	1.0	176.3
Urban household	16.3	0.0	11.6	3.1	85.0	33.3	149.3
Rural household	67.3	0.0	3.2	0.0	0.0	7.3	77.7
Total	537.7	182.9	991.8	20.1	471.9	387.2	2,591.6
2030							
	Coal	Coke	Petroleum	Natural	Thermal		
	Coal	Coke	Petroleum	Gas	Power	Electricity	Total
Agriculture	37.2	0.0	7.4	0.0	0.0	9.9	54.5
Industry	314.3	184.8	1,014.5	15.4	444.5	536.6	2,510.1
Service Industry	116.5	0.0	35.7	16.7	118.9	54.7	342.6
Transportation	0.0	0.0	262.9	0.0	0.0	1.7	264.6
Urban household	13.2	0.0	16.2	6.0	123.3	59.9	218.5
Rural household	65.9	0.0	6.0	0.0	0.0	13.8	85.8
Total	547.1	184.8	1,342.8	38.1	686.7	676.6	3,476.1

Table 25: Final Energy Consumption by Sector, Policy Scenario, 10,000 Ton Standard Coal

2007	Natural Thermal						Total
	Coal	Coke	Petroleum	Gas	Power	Electricity	
Agriculture	24.2	0.0	2.3	0.0	0.0	1.8	28.3
Industry	120.3	90.2	455.2	1.7	170.5	128.8	966.7
Service Industry	62.8	0.0	14.1	0.0	41.0	9.3	127.2
Transportation	0.0	0.0	49.8	0.0	0.0	0.3	50.1
Urban							
Household	12.0	0.0	4.6	1.1	44.3	12.0	74.0
Rural Household	39.8	0.0	1.1	0.0	1.5	2.6	45.0
Total	259.1	90.2	527.1	2.8	257.3	154.8	1,291.3
2010							
2010	Natural Thermal						Total
	Coal	Coke	Petroleum	Gas	Power	Electricity	
Agriculture	30.5	0.0	4.1	0.0	0.0	3.2	37.8
Industry	163.6	136.2	578.1	3.6	196.1	162.3	1,239.8
Service Industry	84.8	0.0	20.9	1.2	56.2	16.3	179.3
Transportation	0.0	0.0	108.6	0.0	0.0	0.5	109.0
Urban household	14.2	0.0	8.0	1.7	53.6	16.9	94.4
Rural household	50.1	0.0	2.0	0.0	0.0	3.6	55.7
Total	343.2	136.2	721.7	6.5	305.8	202.7	1,716.1
2020							
2020	Natural Thermal						Total
	Coal	Coke	Petroleum	Gas	Power	Electricity	
Agriculture	35.4	0.0	5.4	0.0	0.0	5.7	46.5
Industry	237.2	166.2	682.2	8.2	270.6	275.9	1,640.2
Service Industry	114.5	0.0	27.1	8.8	78.6	32.2	261.2
Transportation	0.0	0.0	173.7	0.0	0.0	1.0	174.7
Urban household	16.0	0.0	11.2	3.2	83.6	33.5	147.6
Rural household	65.2	0.0	3.2	0.0	0.0	7.2	75.6
Total	468.2	166.2	902.7	20.3	432.8	355.6	2,345.8
2030							
2030	Natural Thermal						Total
	Coal	Coke	Petroleum	Gas	Power	Electricity	
Agriculture	36.1	0.0	7.0	0.0	0.0	9.7	52.8
Industry	218.3	161.2	770.8	15.4	365.3	413.8	1,944.8
Service Industry	104.2	0.0	35.3	16.7	116.4	53.2	325.7
Transportation	0.0	0.0	260.6	0.0	0.0	1.7	262.2
Urban household	13.0	0.0	15.7	6.2	121.2	60.3	216.4
Rural household	61.3	0.0	6.0	0.0	0.0	13.6	80.9
Total	432.7	161.2	1,095.4	38.3	602.9	552.3	2,882.8

Based on the energy consumption in each scenario, the CO₂ emission is calculated (see Figure 8).

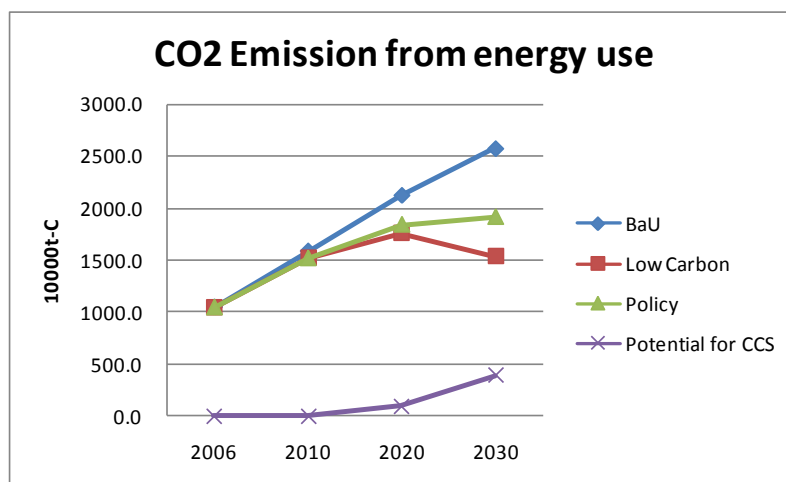


Figure 8: CO₂ Emission by Energy Consumption of Jilin City

7 Conclusion

According to the result of scenario analysis above, the energy demand of Jilin will continue to increase obviously in future. Under the baseline scenario, the primary energy demand will increase from 15.62 million tons of standard coal to 31.26 million in 2020 and 39.34 million in 2030. Among them, coal will still be the main energy, accounting for 59% in 2030.

However, because of various energy policies, the primary energy demand under policy scenario will be 28.18 and 33.51 million tce in 2020 and 2030 respectively. Among them, coal will account for 55.5% and 53.7%, while the proportion of nuclear power will be up to 5% and 8%, and that of wind power will be up to 2% and 3%.

If Jilin City treats low- carbon economic development strategy as one of the key point of social economic development, further CO₂ reduction measure can be taken into account, especially the potential of CCS application in Jilin.

It is revealed in many researches that technology advancement plays a more and more important role in climate change mitigation. As a great developing country, China is experiencing economic takeoff, thus technology means a lot to energy saving and environment and climate change mitigation. And most of the technology can meet the need of energy saving and environment protection in both short and long term. Thus, the technology strategy can be combined with energy and environment policy. During the study on technology development of Chinese industries, it is found that

many technologies available now contributes a lot to energy saving, and reduces green house gas emission as well (see Table 26). Besides, the technologies are supported by the government, which is supposed to be popularized before 2020. Furthermore, climate change can be used as a promotion factor to attract more capital and international cooperation, which will propel the popularization of the technologies.

Table 26: Technologies Contributive to Green House Gas Reduction in Short and Mid Term

Sector	Technologies
Steel Industry	Large size equipment (Coke Oven, Blast furnace, Basic oxygen furnace ,etc.), Equipment of coke dry quenching, Continuous casting machine, TRT Continuous rolling machine, Equipment of coke oven gas, OH gas and Blast Furnace gas recovery , DC-electric arc furnace
Chemical Industry	Large size equipment for Chemical Production, Waste Heat Recover System, Ion membrane technology, Existing Technology Improving
Paper Making	Co-generation System, facilities of residue heat utilization, Black liquor recovery system, Continuous distillation system
Textile	Co-generation System, Shuttleless loom, High Speed Printing and Dyeing
Non-ferrous Metal	Reverberator furnace, Waste Heat Recover System, QSL for lead and zinc production
Building Materials	Dry process rotary kiln with pre-calciner, Electric power generator with residue heat, Colburn process, Hoffman kiln, Tunnel kiln
Machinery	High speed cutting, Electric-hydraulic hammer, Heat Preservation Furnace
Residential	Cooking by gas, Centralized Space Heating System, Energy Saving Electric Appliance, High Efficient Lighting, Solar thermal for hot water, insulation of building and energy efficient windows
Service	Centralized Space Heating System, Centralized Cooling Heating System, Co-generation System, Energy Saving Electric Appliance, High Efficient Lighting
Transport	Hybrid vehicle, advanced diesel truck, Low Energy Use Car, Electric Car, Fuel cell vehicle, Natural Gas Car, Electric Railway Locomotives, public transport development
Common Use Technology	High Efficiency Boiler, Fluid Bed Combustion Technology, High Efficiency Electric Motor Speed Adjustable Motor, Centrifugal Electric Fun, Energy Saving Lighting
Power Generation	Super critical unit, Natural Gas Combined Cycle, Pressured Fluid Bed Combustion Boiler, Wind turbine, Integrated Gasification Combined Cycle, Smaller Scale Hydropower, biomass based power generation

Based on the study on energy and emission of China and the whole world in the long term, it is found that the following technologies will play an important role: modern renewable energy production technology (solar power etc.), advanced nuclear power system, fuel cell, IGCC/ advanced clean coal technology/ CCS, advanced gas turbines, unconventional natural gas and raw oil production technology, synthetic fuel production technology and advanced transportation technology with ultra-low energy consumption and no emission.

The technologies have already drawn the public attention; however, because of the lack of investment on the research and development, the technology can only be applied in developed country. However, development of the technologies is the mutual need of the whole world. With the strengthening of economic power and technical competence, it is possible for some technology to attract investment on the research and development. For example, IGCC and clean coal technology have large potential in Chinese market, while they are confronted with large uncertainty in other countries with little coal consumption. Thus, there is good opportunity for China to develop such technologies, and if China can lead the develop process, both the environment and economic development can benefit from it. Under the low green house gas emission scenario, technology development strategy should take the climate change into account, to realize the target of concentration decrease. It is a potential emission reduction opportunity for China and other countries to cooperate on the research and development of the technology under the climate change framework. Jilin should make some effort to participate in developing advanced technology, make the most of opportunities of developing advanced technologies, enhance local strength of researching and manufacturing, and improve the economical competitiveness.

According to the scenario analysis above, measures to realize low energy policy scenario includes:

- 1) Adjust the economic structure, promote the industries with high added value and low energy consumption, and limit the manufacturer of productions with high energy consumption. The government and industries should be more aware of and pay attention to the importance of combining it with the short and mid term planning. Jilin has already faced the problem of economic competence, which can be treated as a chance to adjust the economic structure. Jilin is supposed to make the best of the opportunity to develop the low-carbon economic, taking the advanced country (e.g. EU country) or areas in developed country (e.g. California, US).
- 2) Fully implement the energy-saving policy, and set the energy-saving target in “11th five year plan” as a long term policy.

- 3) The energy- saving target of Jilin is higher than the national average, and some mature energy- saving policy has been widely accepted, so Jilin can further take other measures, such as implementing stricter energy-saving standard or local energy tax/ resource tax etc..
- 4) Encourage more energy-saving investment, take the advantage of strong economic power in the area development, lead the private investment by public investment, and build an advanced economic system of low energy consumption.
- 5) Build an energy utilization system based on the most advanced technologies, in order to make the energy using efficiency keep ahead both at home and abroad between 2020 and 2030.

According to the policies and actions of sustainable development, energy saving, and regenerative energy, we can conclude that the policies can be implemented in a long term. The technologies mentioned in Table 5 may have a widely application before 2020. The important next generation technologies, including IGCC, advanced coal conversion, wind energy generation, Solar PV, biomass power generation and gasification, advanced automobile technology, advanced nuclear technology, are all researched and developed with the government support. Some achievement has gotten already, and may be in a international leading position in future.

The model analysis also indicates: It will take a long term to realize the low carbon Scenario. The innovations of technology, conception, consumption behavior, and the policy mechanism are necessary. The technology innovation, mainly includes implementing and extending the advanced technology, new materials, advanced process flow and low carbon consumptions, in fields of electric generation, industry energy saving, energy saving consumable, transportation, and Energy-saving building. Further more, we need to pay more attention to extend the application of advanced technologies, such as industrial boiler, furnace. The policy mechanism innovation mainly includes making the suitable policy to the low carbon economic, strict standard of energy efficiency and low carbon commodity, tax collection on carbon emission, and the encourage policies to establish the markets of low carbon and energy efficiency.

The advanced technologies and policies to realize low carbon scenario is shown in Table 27.

Table 27: Advanced Technologies and Policies to Realize Low Carbon Scenario

Department	Advanced Technologies and Policies
Building Industry	<p>The energy saving standards of 65% and 75% are implemented, and the standards will increase year by year. Buildings with characteristics of high energy efficiency, sustainable (Green) buildings, applying advanced refrigeration and heating technologies are the main trend. Encourage the technology applications of ice storage and heat storage air controllers, combined cooling, heating and power system, fan and pump with function of frequency conversion in Central air conditioning and heating system, electric equipments and heat pump, to save energy and water, Solar water heater, Heat cost Allocator. Establish the energy management system, and the technical consultation and information network. Realize the audit of energy and DSM. Implement the energy efficiency standard and identification to all the electrical equipments. The technologies include solar home system, regenerative energy application, thermal energy storage heat exchanger, new building materials, energy saving lamp and so on.</p>
Transportation	<p>Hybrid vehicle, electrical cars, advanced diesel oil automobiles, public traffic system, biologic fuel. Increase the purchasing and using cost of personal automobiles. Provide allowance and reduce tax for efficient and environmental automobiles. Traffic demand management (TDM). Develop the traffic with non-motor vehicles. Improve economy of fuel by the compulsory standards or voluntary agreement. Develop public traffic. Improve public consciousness. Exploit substitute energy (such as hydrocracking), variable valve controls-VVT, fuel battery automobile, regenerative energy application technology, substitute mode for non-traffic transportation.</p>
Industry	<p>Low-carbon intensive and high energy efficiency production technology, high efficient, industry boiler, advanced industry energy saving technology (in the fields of iron and steel system, architecture materials, glass, chemical industry and so on), efficient electromotor, re-use and recycling of waste. Establish more rigid standards of energy efficiency and low-carbon commodity. Reduce the allowance and tax preference of high energy-consuming industry. Develop trade of carbon emission. Definite the energy price/carbon tax/energy tax, tax reduction/preference, government financial support, laws. Establish the policy of industry development, and the plan of technology research. Increase the investment on research and exploitation. Establish the mechanism of technology innovation, new technology demonstration. Develop circular economy; enlarge the market of technologies; import advanced technologies; Adjust industry structure. Take advantage of the energy resources; intensify energy efficiency standards and markings. Develop voluntary agreement and international cooperation. Improve the consciousness of energy saving and greenhouse gas emission reduction.</p>
Energy Supply (Electric Generation)	<p>IGCC, CCGT, nuclear power, CHP, distributed electric power generation system, biological materials application technology, solar energy for electric generation, biomass liquefaction, hydropower development, advanced fuel forest, wind energy, solar energy, clean coal, and biotechnology.</p>

Table 27: Advanced Technologies And Policies to Realize Low Carbon Scenario (Continued 1)

Department	Advanced Technologies and Policies
Economic Incentive Policies	Pay equal attention to tax collection and voluntary agreement, and encourage enterprises to take part in the voluntary agreement activities. Give financial support to enterprises which put greenhouse gas emission reduction activities into effect. Implement the preferential tax to energy saving products. Special support fund for energy saving should be established by the governments. Start the government purchasing plan so as to supply the bargain regenerative energy. Encourage the exploiting enterprises to build advanced energy saving and environmental buildings. Encourage consumers to buy energy saving and environmental buildings.
Domestic and Oversea Low Carbon Cooperation	Sufficiently make use of different chances in international cooperation, and expand the international cooperation of financing and technology transference, including the CDM projects present, and the potential opportunity of carbon trade. There are still mass of cooperation opportunities at present.
CCS Technology	Take advantage of the demonstration projects organized by the international cooperation and notional programming, in order to promote CCS application in the terminal departments of energy consumption of electricity, cement, steel and so on.