13th FYP development and utilization plan for geothermal energy

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To the Development and Reform Commissions (energy bureaus) of provinces, autonomous regions, directly-controlled municipalities and the XPCC, the Land and Resources Office, local branches of the National Energy Administration, State Grid Corporation, Southern Power Grid Corporation, the National Geothermal Energy Center, the China Geological Survey bureau, the Special Committee for Geothermal energy at the China Energy Society, and the National Renewable Energy Center：

In order to promote the sustained and healthy development of the geothermal energy industry, to promote the construction of a clean, low-carbon, safe and efficient modern energy system, in accordance with the requirements of the "Renewable Energy Law", on the basis of the "13th Five Year Development Plan for energy" and the "13th Five Year Development plan for renewable energy", we have organized the preparation of the "13th Five Year Plan for the development and utilization of geothermal energy", and this is hereby issued to you; please ensure its comprehensive and actual implementation。

Annex：13th Five Year Plan for the development and utilization of geothermal energy

National Development and Reform Commission

National Energy Administration

Ministry of Land and Resources

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Foreword

Geothermal energy is a green and low-carbon, sustainable renewable energy, with large reserves, widely distributed, clean and environmentally friendly, stable and reliable characteristics, and is a practical, feasible and competitive form of clean energy。 China geothermal resources are plentiful, the market has great potential, and its development outlook is vast。 Accelerating the development and utilization of geothermal energy is not only of great significance in adjusting the energy structure, in conserving energy, reducing emissions, and improving the environment, but also has a significant pull effect on the cultivation of new industries, the promotion of 'new-style urbanization', and on increasing employment, and is an important measure in promoting the construction of an ecological civilization。

In order to implement the "Renewable Energy Law", and on the basis of the "13th FYP development Plan for Renewable Energy", we drafted the "13th Five Year Plan for the development and utilization of geothermal energy"。 The Plan elaborates the guidelines and objectives, key tasks, major project layout of geothermal energy development and utilization, as well as its safeguards measures for implementation, and forms the basis for the development and utilization of China's geothermal energy during the "13th Five-Year Plan" period。

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1. Basis and background of the plan

(i) Development status

In the 1970's, China began geothermal surveying, exploration and utilization, constructed the Guangdong Fengshun and 6 low-temperature geothermal power stations, and built the Yangbajing geothermal power station in Tibet in 1977。Since the 1990's, Beijing, Tianjin, Baoding, Xianyang, Shenyang and other cities have carried out low-temperature geothermal district heating, health tourism, agricultural and other direct uses。Since the beginning of the current century, district heating (cooling) with heat pumps and development and utilization of other types of shallow geothermal energy has gradually accelerated。

1) Resource potential

According to results of the 2015 China Geological Survey by the Ministry of Land and Resources, the amount of extractable shallow geothermal energy resources in the 336 cities at prefecture-level or above is equivalent to 700 million tons of standard coal per year；nationwide hydrothermal resources are equivalent to 1.25 trillion tons of standard coal, with the amount of extractable resources equivalent to 1.9 billion tons of standard coal per year；hot dry rock resources at depths of 3,000 to 10,000 meter are equivalent to 856 trillion tons of standard coal。

Resource type		**Geographical distribution**	
Shallow geothermal resources		Southern part of Northeast China, North China, Yangtze and Huaihe River Basin, Sichuan Basin and eastern part of Northwest China	
Hydrothermal resources	Medium and low temperature	Sedimentary basin	Basins in the central part of East China and the Cenozoic plains, including the North China Plain, Yellow River - Huaihe basin, northern Jiangsu plains, Jianghan Plain,

			Songliao Basin, Sichuan Basin, Ordos basin ring, and other areas
		Mountain uplift	Southern Tibet, western Sichuan and western Yunnan, southeast coast, Shandong Peninsula, Liaodong Peninsula, northern side of the Tianshan Mountains and other regions
	High temperature	Southern Tibet, Western Yunnan, Western Sichuan and other regions	
Hot dry rock geothermal resources		Mainly in Tibet, followed by Yunnan, Guangdong, Fujian and other southeast coastal areas	

Table 1. Distribution of geothermal resources

2) Development and utilization status

At present, shallow and hydrothermal district heating (cooling) technology has basically matured。 Shallow geothermal energy applications mainly utilize heat pump technologies, which have seen an annual growth rate of more than 30% since 2004, and application extended throughout the country. 80% of this has been concentrated in the north and in the southern part of the northeast, including in Beijing, Tianjin, Hebei, Liaoning, Henan, Shandong and other areas。 By the end of 2015, the nationwide floor area with district heating (cooling) supplied by shallow geothermal energy reached 392 million square meters, and nationwide floor area with district heating supplied by hydrothermal energy reached 120 billion square meters。 The annual geothermal energy utilization is equivalent to approximately 20 million tons of standard coal。

In geothermal power generation, high-temperature dry steam power generation technology is the most mature and has the lowest production cost; high temperature flash steam is second; whilst the technical maturity and economics of medium and low temperature geothermal power generation still need to be improved。 Due to the characteristics of China's geothermal resources and its thermoelectric power generation needs, in recent years, total flow power generation in China has rapidly developed, whilst hot dry rock power generation systems are still in the experimental development stage。 In the early 1970s, medium and low-temperature geothermal power generation stations were built in Fengshun, Guangdong Province, Huailai, Hebei Province, Yichun, Jiangxi Province, and other places。 In 1977, China built the 24 MW Yangbajing medium and high temperature geothermal power generation station in Tibet。 By the end of 2014, China's total installed capacity of geothermal power generation reached 27.28 megawatts, ranking number 18 globally。

Table 2. Status of geothermal energy development and utilization (as of the end of 2015)

	Shallow geothermal district heating/cooling area (1000 m2)	Hydrothermal district heating area (1000 m2)	Power generation capacity (MW)
Beijing	40,000	5,000	
Tianjin	10,000	21,000	
Hebei	28,000	26,000	0.4
Shanxi	5,000	2,000	
Inner Mongolia	5,000	1,000	
Shandong	30,000	10,000	
Henan	29,000	6,000	
Shaanxi	10,000	15,000	
Gansu	4,000	0	
Ningxia	2,500	0	
Qinghai	0	500	
Xinjiang	3,000	1,000	
Sichuan	10,000	0	
Chongqing	7,000	0	
Hubei	12,000	0	
Hunan	2,000	0	
Jiangxi	6,000	0	
Anhui	18,000	500	
Jiangsu	25,000	500	
Shanghai	10,000	0	
Zhejiang	22,000	0	
Liaoning	70,000	2,000	
Jilin	2,000	5,000	
Heilongjiang	3,000	6,500	
Guangdong	5,000	0	0.3
Fujian	1,000	0	
Hainan	1,000	0	
Yunnan	1,500	0	
Guizhou	8,000	100	

Guangxi	22,000	0	
Tibet	0	0	26.58
National	392,000	102,100	27.28

(ii) Development trends

Within the "13th FYP" period, following modernization and improvement of people's living standards as well as the growth of heating demand in Southern China, there will be a lot of room for growth for centralized district heating。 At the same time, provinces (autonomous regions, municipalities) face requirements of reducing coal consumption, preventing and controlling air pollution, and increasing shares of renewable energy consumption. This provides a rare opportunity for the development of geothermal energy, although there are currently still a lot of constraints for the development of geothermal energy, mainly in the low level of resource exploration, an imperfect administrative management system, a lack of unified technical specifications and standards, etc.。

2. Guidelines and objectives

(i) Guiding ideology

Implement the spirit of the 18th National Congress and the third, fourth, fifth and sixth plenary sessions of the 18th Central Committee of the Communist Party of China, and comprehensively promote the energy production and consumption revolution strategy. Guided by adjustments to the energy structure, prevention and control of air pollution, reduction of greenhouse gas emissions, and promotion of the 'new-style urbanization', rely on scientific and technological progress, innovate geothermal energy development and utilization models, and actively cultivate geothermal energy markets. In accordance with overall requirements for advanced technology, environmental friendliness, and economic viability, comprehensively promote the effective utilization of geothermal energy。

(ii) Basic principles

Adhere to cleanliness and efficiency, sustainability and reliability。 Strengthen the development and utilization planning of geothermal energy, strengthen comprehensive administrative management, and establish systems for resource exploration and evaluation, project development and evaluation, environmental monitoring and administrative management。 Set strict environmental regulation for geothermal energy utilization, to ensure that there is extraction of heat and not of water, and that water

	"13th FYP" period additions			2020 Cumulative		
	Shallow geothermal heating/cooling area (1000 m2)	**Hydrothermal district heating area (1000 m2)**	**Power generation capacity (MW)**	**Shallow geothermal heating/cooling area (1000 m2)**	**Hydrothermal district heating area (1000 m2)**	**Power generation capacity (MW)**
Beijing	40,000	25,000		80,000	30,000	
Tianjin	40,000	25,000	10	50,000	46,000	10
Hebei	70,000	110,000	10	98,000	136,000	10.4
Shanxi	5,000	55,000		10,000	57,000	
Inner Mongolia	4,500	18,500		9,500	19,500	
Shandong	50,000	50,000	10	80,000	60,000	10
Henan	57,000	25,000		86,000	31,000	
Shaanxi	5,000	45,000	10	15,000	60,000	10
Gansu	5,000	1,000		9,000	1,000	
Ningxia	5,000			7,500		
Qinghai		2,000	30		2,500	30
Xinjiang	5,000	2,500	5	8,000	3,500	5
Sichuan	30,000		15	40,000		15
Chongqing	37,000			44,000		
Hubei	62,000			74,000		
Hunan	40,000			42,000		
Jiangxi	30,000			36,000		
Anhui	30,000			48,000	500	
Jiangsu	60,000	2,000	20	85,000	2,500	20
Shanghai	27,000			37,000		
Zhejiang	30,000			52,000		
Liaoning	10,000	10,000		80,000	12,000	
Jilin	10,000	10,000		12,000	15,000	
Heilongjiang	10,000	16,000		13,000	22,500	
Guangdong	20,000		10	25,000		10.3
Fujian	4,000		10	5,000		10
Hainan	5,000		10	6,000		10
Yunnan	1,000		10	2,500		10

Guizhou	20,000	500		28,000	600	
Guangxi	14,000			36,000		
Tibet		2,500	350		2,500	376.58
National	726,500	400,000	500	1,118,500	502,100	527.28

resources are not polluted, and effectively guarantee the clean development and sustainable use of geothermal energy。

Adhere to policy pull and market push。Strengthen policy guidance, promote efficient and sustainable development of the entire sector, and realize mutually beneficial cooperation。Give full play to the basic role of the market in allocation of resources, encourage participation of all kinds of investment entities in of geothermal energy project development, and create a fair market environment。

Adhere to 'according to local conditions' and orderly development。On the basis of geothermal resource characteristics and local energy needs, according to local conditions, carry out development and utilization of shallow geothermal energy and hydrothermal energy, and carry out experimental development and utilization of hot dry rock geothermal energy。Considering the geothermal resource characteristics and the various types of geothermal energy technologies, orderly develop geothermal power generation, district heating, and various forms of comprehensive utilization。

(iii) Development targets

In the "13th FYP" period, additions of geothermal district heating (cooling) floor area will be 1.1 billion square meters, of which：additions of floor area supplied with shallow geothermal district heating (cooling) of 700 million square meters；additions of floor area supplied with hydrothermal district heating (cooling) of 400 million square meters。Newly installed capacity of geothermal power generation will be 500 MW。By 2020, floor area supplied with geothermal district heating (cooling) will total 1.6 billion square meters; the installed capacity of geothermal power generation will be circa 530 MW。By 2020, the annual utilization of geothermal energy will be equivalent to 70 million tons of standard coal; the annual utilization of geothermal district heating will be equivalent to 40 million tons of standard coal。The annual utilization of geothermal energy in the Jing-Jin-Ji region will reach circa 20 million tons of standard coal。

Table 3. Geothermal energy development goals

Over the "13th FYP" period, form a relatively comprehensive administrative management and policy system for the development and utilization of geothermal energy, master key core technologies in the geothermal manufacturing industry, and form a relatively

comprehensive system of standards and monitoring for equipment manufacturing and project construction for geothermal energy development and utilization。

Over the "13th FYP" period, carry out hot dry rock research and development work, and construct hot dry rock demonstration projects。 Through construction of demonstration projects, realize breakthroughs in hot dry rock resource evaluation and drilling site selection, and in key technologies such as hot dry rock drilling and project construction and high efficiency heat extraction from hot dry rock heat reservoirs etc., realizing breakthroughs in bottlenecks for the development and utilization of hot dry rock。

3. Key tasks

(i) Organization of geothermal resource exploration and priority area evaluation

Over the "13th FYP" period, on the basis of the current development and utilization of geothermal resources in China, survey the geological conditions, thermal storage characteristics and the quality and quantity of geothermal resources in China's major hydrothermal zones (fields), and its shallow geothermal energy and hot dry rock development zones, and further evaluate the economic and technological conditions for their extraction, providing a basis for their rational development and utilization。

Support the active participation of capable enterprises in geothermal resource exploration and evaluation, support enterprises involved in exploration and evaluation with priority provision of geothermal resource business licenses, and integrate exploration and evaluation data into the national data management platform。

Box 1. Key areas for geothermal resources exploration and evaluation

Shallow geothermal resources	Main cities and central towns in Beijing, Tianjin, Hebei, Shandong and Henan, and in the middle and lower reaches of the Yangtze River region
Hydrothermal resources	Songliao Basin, Bohai Bay Basin, Hehuai Basin, Jianghan Basin, Fenhe- Weihe Basin, Central Ordos Basin, Yinchuan Plain and other regions
Hot dry rock geothermal resources	Tibet-Yunnan high temperature geothermal belt, southeast coastal region, North China, Songnen plains and other areas

(ii) Actively promote hydrothermal district heating

In accordance with the "combination of centralized and distributed forms" approach to promote hydrothermal district heating, and with "extract heat, not water" as the guiding principle, carry out substitution with clean heating alternatives in the traditional district heating zones, especially in the Jing-Jin-Ji region and Shandong and Henan, which have more developed economies but stronger environmental constraints, and in the fragile ecological environment of the Qinghai-Tibet Plateau and adjacent areas. Incorporate

hydrothermal district heating into the urban infrastructure construction, with centralized planning and comprehensive development。

(iii) Strongly promote the utilization of shallow geothermal energy

Over the "13th FYP" period, following the approach of "in accordance with local conditions, intensive development, strengthen supervision, focus on environmental protection", develop and utilize shallow geothermal energy。 Through technological progress and standardized administrative management, solve the current problems in development of shallow geothermal energy, and strengthen the development and utilization of shallow geothermal energy in Southern China, which has strong demand for district heating and cooling。 While paying attention to the use of shallow geothermal energy in the traditional urban areas, attention should simultaneously be paid to the demand for shallow geothermal district heating (cooling) in new urban areas。

(iv) Geothermal power generation projects

Build high-temperature geothermal power generation projects in Tibet, western Sichuan and other areas with high-temperature geothermal resources ; Build a number of low-temperature geothermal power generation projects in North China, Jiangsu, Fujian, Guangdong and other regions。 Establish and improve mechanisms to support geothermal power generation, establish a policy system on aspects including power grid connection, peak load regulation, and feed-in tariffs for geothermal power generation。

(v) Strengthen the development of key technologies

Carry out research on geothermal resource evaluation, efficient heat transfer, high temperature heat pumps, high temperature drilling, and economic re-injection technologies ; Carry out in-depth research and development of underground heat exchanger technologies, and thoroughly carry out research and development of medium and low temperature hydrothermal power generation technologies and equipment ; Carry out feasibility studies for hot dry rock power generation test projects, select sites, and carry out the necessary early stage exploration work。

(vi) Strengthen construction of information monitoring and statistics systems

Establish geothermal resources information monitoring systems for the quality of the water used in the processes of shallow and hydrothermal energy development and utilization, rock and soil temperatures, water levels, water temperatures, and geological environmental calamities。 Establish a national monitoring system for the development and utilization of geothermal energy, using modern information technology, for the systemic monitoring and dynamic evaluation of the exploration, development and utilization of geothermal energy。

(vii) Strengthen industrial service systems

Perfect the geothermal energy industry system, in the industrial chain surrounding the development and utilization of geothermal energy, standard and norms, personnel training and service systems。 Improve the specifications of standards regarding the exploration of geothermal resources, drilling, pumping, and re-injection. Determine standards for the overall design, construction and operation of geothermal power generation, the heating and cooling of buildings, and comprehensive utilization projects 。Strengthen the testing and certification of equipment for the utilization of geothermal energy, establish information monitoring systems for the industry and the development and utilization of geothermal energy, improve the statistical information on geothermal resources and their utilization, increase efforts at personnel training related to the utilization of geothermal energy related, and actively promote international cooperation in the utilization of geothermal energy。

4. Major project layout

(i) Hydrothermal district heating

On the basis of existing resources and market demand, the Jing-Jin-Ji region, Shanxi (Taiyuan city), Shandong (Dongying & Heze), Heilongjiang (Daqing), and Henan (Puyang) have been selected for the construction of major hydrothermal district heating projects。 Using "balanced extraction and re-injection, indirect heat transfer" or "underground heat transfer" technologies, achieve the sustainable development of geothermal resources。

Box 2. Layout of major hydrothermal district heating projects

Hebei	Focus on promoting hydrothermal resources development in Baoding, Shijiazhuang, Langfang, Hengshui, Cangzhou, and Zhangjiakou. Over the "13th FYP" period, additional floor area supplied with hydrothermal district heating will be 110 million square meters
Shaanxi	Focus on promoting hydrothermal resources development in Xi'an, Xianyang, Baoji, Weinan, Tongchuan and other cities (districts). Over the "13th FYP" period, additional floor area supplied with geothermal district heating will be 45 million square meters。
Shanxi	Focus on promoting the development of hydrothermal district heating in Taiyuan High-tech Zone, Taiyuan Economic Development Zone, Taiyuan Science and Technology Innovation City and other areas. Over the "13th FYP" period, additional floor area supplied with geothermal district heating will be 40 million square meters。
Shandong	Focus on promoting geothermal resources development in Dongying and Heze, and the utilization of hydrothermal resources and the waste heat from the Shengli Oilfield in Dongying city. Over the "13th FYP" period, additional floor area supplied with centralized hydrothermal district heating will be 12 million square meters ; with the most immediate focus on Heze City, but simultaneous actively developing markets in Dingtao, Juancheng and other areas, additions to floor area supplied with geothermal district heating will be 12 million square meters 。
Heilongjiang	Focus on development of geothermal district heating, health spas, mineral water production and agricultural uses in Lindian, Daqing City, Taikang, Dongfeng New Village, Rangxi and other areas. Over the "13th FYP" period, additions to floor area supplied with geothermal district heating will be 10 million square meters。
Henan	Focus on geothermal resources in Qingfeng County of Puyang City. Over the "13th FYP" period, additions to floor area supplied with centralized geothermal district heating will be 4 million square meters。

(ii) Shallow geothermal energy utilization

Along the Yangtze River Economic Zone, in view of the urgent needs of urban residents for district heating, accelerate the geothermal energy primarily through use of heat pump technologies, reduce large-scale coal-fired centralized district heating, and reduce the twin pressures of supply security and pricing of natural gas-based district heating。 Comprehensively promote shallow geothermal heating (cooling) project construction, focusing on Chongqing, Shanghai, South Jiangsu urban agglomeration, Wuhan and the surrounding urban agglomeration, Guiyang, Yinchuan, Wuzhou, and the Sanshui District of Foshan 。

Box 3. Layout of major shallow geothermal heating (cooling) projects

Chongqing	Focusing construction on the Liangjiang New District in Chongqing, additional floor area supplied with shallow geothermal heating (cooling) will be 37 million square meters over the "13th FYP" period. By 2020, floor area supplied with shallow geothermal energy will account for more than 50% of newly added floor area。
Shanghai	Over the "13th FYP" period, additions to floor area supplied with geothermal district heating (cooling) will be 27 million square meters。

South Jiangsu urban agglomeration	Over the "13th FYP" period, additions to floor area supplied with geothermal district heating (cooling) will be 61 million square meters, in Nanjing, Yangzhou, Taizhou, Nantong, Suzhou, Wuxi, Zhenjiang, Changzhou and Nanjing and other cities。
Wuhan and the surrounding urban agglomeration	Over the "13th FYP" period, additions to floor area supplied with geothermal district heating (cooling) will be 61 million square meters, in the eight administrative urban areas of Wuhan and the surrounding Huanggang City, Ezhou, Huangshi, Xianning, Xiaogan, Tianmen, Xiantao, and Qianjiang City。
Guiyang City, Guizhou; Wuzhou, Guangxi; Foshan, Guangdong	Over the "13th FYP" period, additions to floor area supplied with geothermal district heating (cooling) will be 5 million square meters。

(iii) Medium and high temperature geothermal power generation

Tibet is located in an area with a global geothermal hotspot, with rich and relatively good quality geothermal resources。 There are over 600 geothermally active areas (points) of various types, ranking first in the country。 Tibet ranks first countrywide in terms of high temperature geothermal energy, with a power generation potential of about 3000 MW, especially in the region south of the Bangongcuo-Nujiang fault zone. The Tibetan area with rich and concentrated high temperature geothermal resources, has a concentrated population, a developed economy, and huge demand for energy, and is therefore a favorable area for the development of large scale high-temperature geothermal power generation。

On the basis of results from a geothermal resources exploration and evaluation of resource potential in Tibet, and on the premise of local electricity demand, 11 high temperature geothermal fields have been selected as priority areas for the "13th FYP" period, being Yangbajing, Yangyi, Ningzhong, Gulu, Gudui, Langjiu, Qupu, Chabu, Quzhuomu, Kawu and Kuma, within the counties of Dangxiong, Naqu, Cuomei, Ga'er, Pulan, Xietongmen, Cuona, Sajia, and Gangba. The total power generation potential of these 11 high temperature geothermal fields is 830 MW; over the "13th FYP" period, planning or orderly construction will start on 400 MW of installed capacity。

(iv) Medium and low temperature geothermal power generation

Construct medium & low-temperature geothermal power generation projects in Eastern China。 Focusing on Hebei, Tianjin, Jiangsu, Fujian, Guangdong, Jiangxi and other areas, following government guidance, gradually develop the market and enterprises, and actively develop medium & low-temperature geothermal power generation。

(v) Hot dry rock power generation

Carry out exploration and development work on geothermal resources at depths of 10 km, and actively carry out testing of hot dry rock power generation. In priority areas such as southern Tibet, western Sichuan, western Yunnan, Fujian, the North China Plain,

Changbai Mountain and other resource-rich areas, through the establishment of 2 to 3 demonstration bases for hot dry rock exploration and development, form a suite of technologies, incubate related enterprises, and accumulate construction experience. Start promotion when the conditions are ripe for it。

5. Implementation

(i) Safeguard measures

1. Research and determine geothermal district heating investment support and geothermal power generation feed-in tariff policies。 Incorporate geothermal district heating into urban infrastructure construction, and provide policy support in municipal land use for project construction, water use and electricity use prices and other aspects。 In combination with the electricity market reform, encourage enterprises engaged in geothermal energy development and utilization to reduce electricity consumption costs through electricity trading。

2. Improve market mechanisms for the development and utilization of geothermal energy 。 Improve existing development models for geothermal energy, and implement integrated development models for exploration, design, construction and operation. Explore the establishment of a tender system for business license for geothermal energy development, and public and private capital partnerships (PPP model)。 Liberalize and remove restrictions to market entry in urban district heating, guiding geothermal energy development enterprises to enter the urban district heating market。

3. Strengthen the administrative management of planning and projects for geothermal energy development and utilization。 On the basis if the overall plan for national geothermal energy development and utilization, co-ordinate the planning and phased development and construction programs for the development and utilization of geothermal energy in different administrative areas。 Strengthen the administrative management of the construction of major projects for the development and utilization of geothermal energy, strictly manage project preparation, acceptance testing, operational supervision and other aspects, and comprehensively coordinate geothermal energy development and utilization with local centralized district heating or electricity supply networks。

4. Perfect the administrative management of the industry for the development and utilization of geothermal energy。 Establish and perfect an administrative management system and technical standards, manage on the basis of laws and regulations, and maintain a good market order for the development and utilization of geothermal energy 。 Develop measures for permits for geothermal prospecting rights and for geothermal

water extraction, and develop measures for the collection and administrative management of geothermal water resources fees。 Establish and perfect geothermal industry standards, implement personnel qualification certification and systems for planning, review and permitting。 Establish a market and environmental monitoring system for geothermal energy utilization。

5. Increase R&D investment in key equipment and technologies。 Upgrade the exploration and resource evaluation of geothermal resources, and the level of economic well re-injection technologies, and form a technological system for the development and utilization of geothermal energy with Chinese characteristics。 Strengthen R&D of low and medium-temperature geothermal power generation technologies, and improve technical roadmaps and enhance the economics of the full suite of technologies for power generation etc., which suit the characteristics of China's geothermal resources。 Support the development of geothermal equipment manufacturing enterprises, and improve the technological level of key equipment such as heat pumps and heat exchangers。

6. Strengthen the supervision of implementation of geothermal energy planning。 In accordance with the "four in one" requirements for planning, policy, regulations, and supervision, establish a well-functioning periodic assessment mechanism for planning, organize supervision of the implementation of planning, compile and publish regulatory reports on the implementation of planning, to serve as an important basis for dynamic adjustments to planning。 Strengthen the coordination of government departments at different levels, and establish a well-functioning information sharing mechanism。

(ii) Implementation mechanisms

1. Strengthen coordination of administrative management of planning。 Energy authorities at the level of provinces (autonomous regions, directly-controlled municipalities) shall, in accordance with national planning requirements, do a good job at drafting and implementing the planning for their administrative area, and earnestly implement the development goals and key tasks included in the national level planning。 Before publishing and implementing local geothermal development planning, there should be coordination with national level energy authorities。

2. Establish a dynamic adjustment mechanism。 Strengthen statistical information on geothermal energy development and utilization, establish an industrial monitoring system, timely review the implementation of planning, and do a good job at mid-term assessment of planning。 Based on results of the mid-term assessment, and in accordance with principles conducive to the development of the geothermal industry, dynamically adjust planning。

3. Organize and implement annual development programs。 Establish well-functioning planning management and implementation mechanisms for the development and utilization of geothermal energy, organize annual development programs for key administrative areas, strengthen the comprehensive coordination of planning and of the implementation of development programs, and properly integrate the development and utilization of geothermal energy with tasks for the connection to electrical or district heating grids。

4. Strengthen operational monitoring and assessment。 A commission of experts will carry out ex-post evaluation of major geothermal energy development and utilization projects。 Establish an information monitoring and management system for geothermal energy utilization, with city-level energy authorities taking the lead in monitoring the utilization of geothermal energy, and furthermore strengthen work on relevant statistics 。

6. Estimation of investment & social and environmental impact analysis

(i) Estimate of the scale of investment

Preliminary estimates are that, over the "13th FYP" period, shallow geothermal district heating (cooling) can generate about 140 billion RMB of investment, hydrothermal district heating can generate about 80 billion yuan of investment, and geothermal power generation can generate about 40 billion yuan of investment, for a total of about 260 billion yuan。 In addition, geothermal energy development and utilization can also lead to the development of a chain of key technologies and equipment manufacturing industries, for geothermal resources exploration and evaluation, drilling, heat pumps, heat transfer, etc.。

(ii) Social and environmental impact analysis

Geothermal resources, with its green, environmental and low pollution characteristics, and whose development and utilization does not emit pollutants or greenhouse gases, can significantly reduce ecological damage due to fossil fuel consumption and fossil fuel extraction processes, and has a significant effect on the improvement of the natural environment and the protection of ecological environment。

By 2020, total annual use of geothermal energy will be equivalent to replacing 70 Mt of standard coal of fossil fuels, the corresponding emission reduction will be 170 Mt of carbon dioxide, with significant energy-saving and emission reduction effects。

The development and utilization of geothermal energy can give new impetus to economic restructuring and 'new-style urbanization', and simultaneously promote the development of industries such as geological exploration, construction, water

conservancy, environmental industries, public sector facilities management and other related industries, and also have significant social benefits through increased employment and benefiting people's livelihood