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Purpose of Geothermal Development should be the Maximizing Benefits

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ABSTRACT

Renewables have very low carbon dioxide emission when compared to conventional all energies. There is very higher capacity factor for geothermal energy. Combining both we can see the comprehensive index of carbon dioxide emission, equals the product of both the CO_2 emission tons for million kWh electricity and the installed capacity MW for annual million kWh electricity. This parameter of MW.t means total CO_2 emission of annual million kWh electricity for someone energy. So, we can see geothermal has the lowest comprehensive index of carbon dioxide emission. It verified that geothermal owns absolute superiority for energy saving and carbon dioxide emission reducing. Nevertheless, geothermal development didn't gain ideal growth and benefits. Geothermal power generation progresses so slow all along. Geothermal direct use has decreased its growth speed in recent years. Hot dry rock development was looked good but without substantial progress in fact. Try to find out the reason, it is due to didn't pay attention to the maximizing benefits. However, it is replaced by some specious watchwords. There was a certain influence due to insufficient policy support. And because it induced less dividend of policy therefore someone came up with the idea for earning money. They use "key technology breakthrough" and "patent" to deceive investment from government and users. It is impetuous and hypocrisy. It has deviated purpose of geothermal development. In addition, deficiency of university professional curriculum made weak awareness on geothermal energy and advanced geothermal technology for the business and society. Based on above analyses for current situation and reasons it was proposed that further reform and innovation is necessary to realize the maximizing benefits, in order to reach the target of peak carbon dioxide emissions and carbon neutralizing, and let geothermal development to make a bigger contribution.

1. ABSOLUTE SUPERIORITY OF CARBON REDUCTION BY GEOTHERMAL ENERGY

There is very great difference of carbon dioxide emission for various energies sources. There is also very great difference of capacity factor for various energies sources. Combining both features we can recommend a index called carbon emission comprehensive index. It will express more clearer that geothermal energy has absolute priority. It is richly deigned by nature.

1.1 Carbon Dioxide Emission Rate

There is highest carbon dioxide emission rate for coal and petroleum. Natural gas praised itself to be as clean energy. But its emission rate is still as high as a half of coal. Take comparison from carbon dioxide emission rate by million kWh electricity for various energies. The emission rate of natural gas is 30 times of renewable energies of very low emission. There is also deferent emission among renewable energies. The emission of biomass and solar PV are higher. Geothermal, wind and hydro powers have lower emission. In addition, nuclear power has lowest emission (Figure 1).

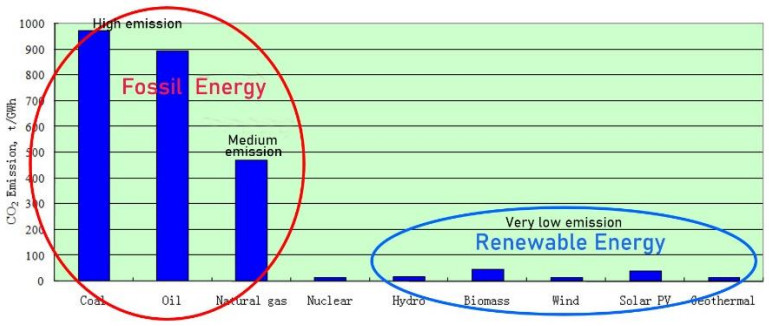

Figure 1: Comparison of CO_2 emission tons per million kWh electricity for various energies

1.2 Capacity Factor

Energy's capacity factor expresses that during annual 8,760 hours how many hours would be available. According to China Statistical Yearbook, fossil energies burned power's annual electricity output kWh divided their installed capacity kW to get the annual production hours, then divided 8,760 hours to get the capacity factor. It is 54% about. Solar energy at night and wind energy when weak wind will lost their ability for power generation. Their capacity factors are 14% and 21% respectively. Capacity factors of hydropower and biomass power are higher as 42% and 52% respectively. The highest capacity factors are geothermal and nuclear powers. Geothermal capacity factor is 72% as highest in renewable energies. Nuclear power has highest capacity factor 88% in all energies (Figure 2).

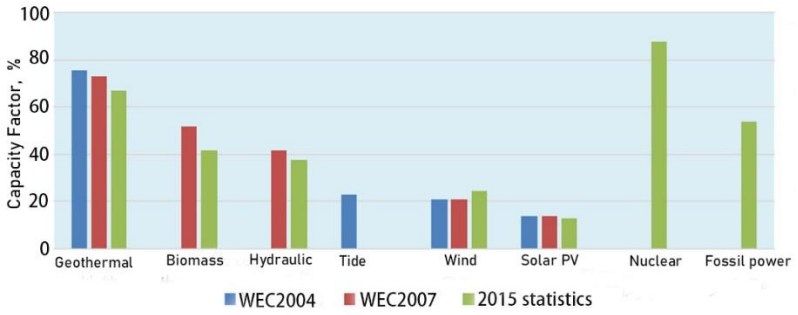

Figure 2: Comparison of capacity factor for various energies

1.3 Carbon Emission Comprehensive Index

Above explanation is two restraining factors. We can recommend a index as called Carbon Emission Comprehensive Index (CECI). Take the emission CO_2 tons per million kWh electricity times the installed capacity which needed for producing million kWh electricity. We get an index with a unit of MW.t. It represents that the energy emitted CO_2 tons for annual generation of million kWh. For convenience we calculated their relative value of %. The results show that coal and petroleum are the championship and runner-up respectively. Their CECI are 206 MW.t and 188 MW.t respectively. Nature gas is the third winner as CECI of 99 MW.t. Then solar PV is 32 MW.t and biomass is 10 MW.t. While wind power and hydropower are 7 MW.t and 5 MW.t respectively. However, geothermal as the lowest CECI in renewables is little higher than 2 MW.t. Finally, the nuclear power's CECI is lowest in all energies as little less than 2 MW.t. Table 1 shows their relative % (Table 1, Figure 3). So, the top carbon dioxide emission of coal is 91 times of geothermal.

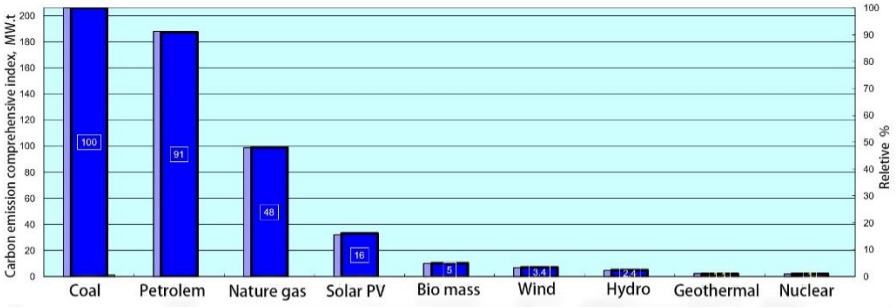

Figure 3: Comparison of carbon emission comprehensive index (CECI) for various energies

Table 1: Comparison of carbon emission comprehensive index (CECI) for various energies

Energy	Emission CO_2 tons/10^6 kWh, t	Capacity factor	Annual hours running, h	Need installed capacity, MW	CECI, MW.t	
	①	②	③ 8760÷②	④ 1,000,000÷③	⑤ ①×④ Value	%
Coal	974	0.54*	4730	0.211	206	100
Petroleum	893				188	91
Nature gas	469				99	48
Solar PV	39	0.14	1226	0.816	32	15.5
Biomass	46	0.52	4555	0.220	10	4.9
Wind power	14	0.22	1927	0.519	7	3.4
Hydropower	18	0.42	3679	0.272	5	2.4
Geothermal	15	0.72	6307	0.159	2+	1.1
Nuclear	15	0.88*	7708	0.130	2-	1

Now we can see so clear at a glance for the series of carbon emissions. Therefore, when we are going to carbon peak and carbon neutral, coal and petroleum have to be restricted, nature gas should use limitedly. We have to advocate the renewables substitution. In all of them geothermal and nuclear powers are the best choice.

2. GEOTHERMAL DEVELOPMENT HAS NOT ACHIEVED IDEAL DEVELOPMENT AND BENEFITS

Since geothermal energy is so superior, geothermal development and utilization should give full play to its advantages and achieve great development. However, it is not the case. The state has supported wind power in the 11th five-year-plan. Wind power had increased 670 times. The state has supported solar power in the 12th five-year-plan. Solar PV power had increased 100 times. The state has supported geothermal power in the 13th five-year-plan. But geothermal power generation completed 4% of planned index only. The status and progress of geothermal development and utilization are extremely lagging behind other renewable energy. Although our geothermal direct use with ground source heat pump has created the greatest amount of use in the world. But the pace of development has also slowed in recent years. We are facing with certain difficulties.

2.1 Geothermal Power Generation Unable to Take a Step

The state's specialized planning of geothermal development of the 13th five-year-plan planned a 500 MW installed capacity for geothermal power generation. Several large state-owned enterprises had expressed their brave words. They willing to complete 200 MW and 100 MW etc. targets. However, one year and two years have passed, but they never started their practice. Why is it? They have been waiting for national policy for feed-in tariff of geothermal power. Because wind power and solar power had obtained their feed-in tariff during the 11th five-year-plan and the 12th five-year-plan respectively. So, they had gotten rapid development then. Due to the subsidies for geothermal power have not been introducing. So the plan of action was never implemented. The reform scheme for Yangbajain geothermal power station of 24.18 MW units has already been approved and signed. However, it is still waiting for the policy issue of feed-in tariff. Even the 13th five-year-plan had passed away. It is still a paper plan.

The achievement of geothermal power generation during the 13th five-year-plan is as following. Private enterprise had completed the first stage 16 MW of Yangyi geothermal power station project and had connected to grid. Yangbajain geothermal power station had become an industrial heritage in 2020 without reconstruction. Other private enterprises had completed several tests of mid-low temperature geothermal power generation. They are 1.6 MW in Ruili, 280 kW in Xianxian and 200 kW in Kangding respectively. So total new installed capacity is 18.08 MW. It is less than 4% of planned target. Yangyi geothermal power station finally selected 16 MW unit from the world's top enterprise of Ormat Technology Ltd. It runs 8,150 hours annually to reach a capacity factor as high as 0.93. Nevertheless, there are some unreasonable aspects on the opposite side of success. Tibet performs the policy on ethnic minorities (taking care of Tibet nationality) so that the grid price is low as 0.25 CNY/kWh. While the grid price in Beijing is 0.375 CNY/kWh. The private enterprise had applied for the feed-in tariff of geothermal power over four years but still no result. They are operating at a loss. And they are defaulted the "Geothermal resources tax" without pay (the tax has promulgated and will be perform). Under such operating complexion who will willing to develop geothermal power generation further? Regardless of state-owner or private enterprises no one like to do a sustain losses business.

2.2 Geothermal Direct Use Encounter Difficulty

Medium-low temperature geothermal direct use has been the strong point of China since 2000. Chinese geothermal direct use without ground source heat pump has accounted for 43.4% of the world's total on the WGC2020+1. Yet there are at least two big problems with the current situation.

2.2.1 Many Places Promote the Underground Heat Exchange and Heat Extraction for Medium and Deep Geothermal

In fact, the underground heat exchange of medium and deep geothermal extracts conductive heat. While conventional hydrothermal type production-reinjection model extracts convective heat. The convective heat is rather higher than conductive heat for several to dozens of times. It is obvious that the underground heat exchange does not pursuing high efficiency. Some people seek ease and comfort. They do not want effort to carried out geological, geochemical and geophysical survey to select best well site. They like to appoint a well site at will. And then labeled with "breakthrough" and "innovation" etc. good names for decoration.

2.2.2 Conventional Geothermal Production-Reinjection Model was Locked-in Artificial Fetters

Geothermal space heating should be the best choice for northern China winter heating. But there are several obstacles. Some local governments issued documents said geothermal exploitation caused surface subsidence and pollution so not permit to geothermal exploitation. More limitations were set up for geothermal reinjection such as have to reinject into the same reservoir, have to use the same geothermal water, have to reinject 100%, exploitation rate depend by reinjection etc. However, such measures have limited geothermal exploitation and benefit. They do not understand that geothermal development should full play maximizing benefit. Geothermal development has experimented for more than hundred years in the world. A set of perfect geothermal reservoir engineering monitoring and management system has been created. There is different particularity for each geothermal field themselves. Developed geothermal field should adapt to own rules for operation themselves. But Chinese administration likes the one-size-fits-all approach. Such flat list prices for above reinjection policy are not tailored to local conditions. It killed the maximizing benefit of geothermal development.

2.3 Hot Dry Rock Drilling Operated in Many Places

Hot dry rock (Enhanced geothermal system) development is world's perspective research topic. Since 1970s study started by US has been for more than 50 years. Research overview paper published in the proceedings of WGC2020+1 showed experiment results from 64 sites worldwide. In general, it still belongs to developing research stage with success or failure. It has not reached the situation for commercial application. It is not necessary to be blooming everywhere. Some developers had applied and gained founds support from local governments by using the bright name of HDR. Because local governments had believed their dissemination for becoming "World's leading". They don't know that there was no possible to complete such topic by a private company. At last decade test drilling operated in about 10 sites but they got a temperature only commonly. A national project carried out for many years waited for fracturing and then tested circulation a few times. Finally it at last tested power generation of 100 kW but only some hours. It was called "Successful on power grid" themselves. What impact and benefits for such projects? It is really wasted resources and fund. Almost no valid achievement.

3. NOT MAXIMIZING THE BENEFIT OF GEOTHERMAL DEVELOPMENT

Geothermal administration divisions had been established since 1980s in several cities i.e. Beijing, Fuzhou and Tianjin etc. in China. These are professional management sections which amount to reservoir engineering management for geothermal fields in foreign countries. They plated positive role at that time including layout and control of geothermal exploration, examining and approving well drilling, arrangement of reinjection and behavior monitoring, resources assessment and utilization advising etc. However, such professional geothermal management disappeared basically in 2010s. Some of them were repealed. Some of them had lost their professional function. In its place came government administration by development and reform committee or city management committee. They are pure administration do not understand geothermal technology. So various chaotic phenomena appeared such as

disapprove new well drilling, random arrange reinjection well drilling, and the one-size-fits-all approach to shut down 1,000 wells etc. And various limitations for geothermal reinjection implementation. All kind of restrictions for geothermal development and utilization has seriously deviated the ultimate aim for maximizing benefit of geothermal development. What you get is an ethereal rhetorical gloss only

Why the reason for this situation? It can be analyzed as follows.

3.1 Policy Support is Insufficient

Geothermal as no-carbon renewable energy is main force of energy saving and emission reduction. Geothermal emission reduction function is 91 times of coal. However, it is not actually supported by the national policy. Wind and solar PV power got the national policy support for the feed-in tariff before. But nothing for geothermal. National Development and Reform Commission (NDRC) said that geothermal power needs submit application for "One project one discussion". However, Yangyi geothermal power station had submitted application since its electricity distributed to grid. Unfortunately, this application had lasted for 3 and half years but so far there is no follow-up. World countries all implement preferential policies for renewable energy i. e. energy policy, economic incentive and sustentation fund etc. But in China, there is a "Tax Law" to levy resource tax on geothermal energy.

3.2 All Sorts of Disguised Slogans Asking for Money

Since there is no dividend of policy support, and there are certain administrative restrictions that must be circumvented, so research institutions and companies thought at last to look for new ways to make money. For such camouflage if adhere to geothermal professional management it can be reviewed and see through.

3.2.1 Research Institutions Assert They Would Realize "Key Technological Breakthroughs"

Governments and concerned agencies hazy heard the superiority of geothermal energy a little, research institutions hope to gain more fund, so they propagated that they have some patents could conquer some key technology. So they asked the government for money.

3.2.2 Business Enterprises Expresses They have "Super Power" New Technology

When administrative order instead of specialized management, whereupon business enterprises created many new nouns themselves to get contracting business and collect high charges. They said they had ability beyond peers and could declare awards of "Innovation". In fact, measured by expertise such things were actually not present or needed. For example, many things are not necessary such as reinjection's scale inhibitor, reinjection in the same reservoir, reinjection using the same water, 100% reinjection etc. Individuation work of geothermal reservoir engineering study can cover and solve all of such "problem". Whole those hard-and-fast rules of one-size-fits-all approach suppress the maximizing benefit of geothermal development. Recently Tianjin geothermal institute introduced that they used surface water which acquired at summer to inject into basement rock reservoir and had achieved remarkable increase in production. This is a smack to those slogans around reinjection. It has actually obtained the maximizing benefit.

3.3 Lack of Real Understanding of Geothermal Energy and Advanced Geothermal Technology

Geothermal energy is a new energy with relatively small scope. Professional geothermal courses in university just started for one year only. For social mass and government administrators the geothermal public acceptance is strangeness. Hence something strange has happened as follows.

3.3.1 Social Aspects

Invite experts of none-geothermal for appraisal and wear a high hat. They compile some new nouns for awards themselves. However, the provided data are incomplete almost for all projects. Arisen fact showed a business model which put money first.

3.3.2 Legal Aspects

Distorting the environmental impact of geothermal development. Lack of incentives mechanism for new energy. A resource tax on renewable geothermal resources has been added. All these had showed checkpoint by checkpoint.

3.3.3 Financial Aspects

The project is not responsible for drilling risk but let the drilling team for it. The construction contract lets the engineering team finish first (advance fund). Project payment default. Loans difficult.

3.3.4 Technical Innovation Aspects

Lack of professional and technical in-depth research. An ostentation display of information and experience. Deceiving and self-deceiving "World Leader". There is no substantial efficiency at all.

In this chaotic situation some fake experts took advantage of this to sell their so-called ideas. And so it came out some administrative documents. Those whitewash local achievements (Face-saving project) but the essence is not conducive to geothermal development.

4. BREAK THE STATUS QUO TO STRIVE FOR MAXIMIZING BENEFIT

It is very obvious that renewable geothermal energy owns absolute advantage of energy saving and emission reduction. But it gets no play. Ignoring geothermal maximizing benefit has impeded the normal use of geothermal function. So, it made the inevitable results for essentially inefficient whitewash and self-deceiving face-saving project. We must recognize and break the current awkward situation to conquer the field. The maximizing benefit of geothermal development has to be our guiding principle. It will lead China geothermal to get free to fly big development.

4.1 Nothing Great can be Done without National Policy Guidance

Geothermal development is new technology of renewable energy and emerging industry. Any emerging industry no matter how much potential advantage it has, at the beginning of its development want to stand out from traditional industries it has to rely on extra support i. e. national policy and financing support etc. The development history of geothermal power generation in the world is reviewed, all the high-speed development stages correspond to the preferential support of the national policy. The survival and development of enterprises need to rely on profit to make money. Even well-known large state-owned enterprises don't run a business for political passion but you know you're losing money. Regardless of the United States in the 20th century or Turkey in the 21st century there was a period of rapid development of geothermal power generation. This is all the support of the national policy corresponding to the *Geotherm Law*. We do not believe that China can mobilize by words alone and no specific preferential subsidy policy to allow China's geothermal power to grow spontaneously. In addition, geothermal resource tax is hanging on the head of geothermal enterprises boulder. The tax law has been enacted but enforcement is largely suspended in many places.

4.2 Adhere to Benefit Maximizing as the Key Point of Technological Innovation

Although China's geothermal industry has achieved the world's first in direct use of medium-low temperature geothermal, that is the ground source heat pump mass movement created the basis which grew up on the industry team. We are nowhere near maximizing our benefit. The truth is that things have been tough in recent years. In fact, if we want to maximize the benefit, we can significantly increase the efficiency by 20to 30 percent with the resources and investment that we have. No problem.

How to pursue the maximizing benefit? There are at least two things to watch out for.

4.2.1 Respect Geothermal Science to Achieve Practical Results Instead of Slogans Flying around

We are going to follow scientific law which owned by any natural science themselves. Don't make up new words to think it could use to overwhelm tradition. Making money by talking is not science and technology. We should gain the trust of users to make a reasonable profit. From both technical and economic feasibilities to pursue maximizing benefit is the most realistic way. Fabricating lies with your mouth can fool your users for a while to swindle high profit. But there was no real technological advance it would fall from the altar in the development of competition.

4.2.2 Pursue Continuous Innovation in Science and Technology instead of Lying to Yourself which Whitewash the Appearance

Science and technology are by no means static. There will always be scientists, engineers in continuous research and innovation. We should love what we do, and always look to further improve efficiency and lower the cost. Relying on technological advances and higher efficiency to embrace new market and new situation. Ground source heat pump in the world has popular developed 40 years and now the growing is slow down. Which means we can't do the same thing and need to be updated and created. The existing proposed multi-energy complementarity and energy storage regulation are very concrete unlock direction. It will effectively enhance the development prospects of geothermal industry. Some projects assembled a lot of new terms and past data was superimposed to look like high-end, magnificent and classy. They fooled the judges and won the first prize. However, the actual effect does not worth popularizing. It is just window dressing.

It can be believed that science would overcome ignorance. China geothermal need to really maximizing the benefit of effort in order to ensure greater progress.

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