Green Energy Localized: the Innovation of local Knowledge in the Case of Micro Hydropower System in Taiwan. (Submitted to 35th 4S Annual Meeting in Tokyo)

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Abstract

As a country, known for original equipment manufacturers (OEM) and relying on technology transfer, Taiwan lags behind European countries, the United States, and Japan in terms of technology. Even so, is it possible that Taiwan can have its own unique technical innovation in the age of green energy, instead of merely relying on the transference of green energy technology? If the answer is positive, what are the characteristics of such technical innovation, specific to Taiwanese society?

This paper focuses on the micro hydropower system, made by Cheng-Shi Liou(劉正獅), a unique innovation that has not been found in any other places. Mr. Liou's local green energy innovation is based on the traditional irrigation system, an infrastructure constructed all over Taiwan. Mr. Liou is an innovator and entrepreneur par excellence, native to Taiwan and born in a typical rural area, Da-bei, Yunlin County(雲林縣大埤鄉), in the period after the World War II, when the Japanese colonization was brought to an end. The only formal education that Mr. Liou received was elementary schooling. While he does not have high achievements in terms of degree, Mr. Liou obtains and even constructs a vast amount of local knowledge. He accumulated many rules of thumb from his experiences as an entrepreneur in the clock repairing, designing and manufacturing business. By appropriating these kinds of local knowledge about levers, gears, chains, and materials, he began his alternative innovative career. First, Mr. Liou invented the Energy-Free Emergency Ladder System that could be started just by the weight of a normal person. Using similar technical rules, Mr. Liou then substituted the weight of water for the weight of persons to start the generator system. In the hilly county in Fujian, China(中國福建), he invented the Weight-driven Power System and held patents in many Asian countries and Australia. Finally, Mr. Liou noticed the irrigation system all over Taiwan's farming fields. Observing and understanding water flows in the channels, he tried to invent another electricity generation system, the micro hydropower system without storing water or building dams. At that moment the water wheel power generation system emerged.

Extending my previous research on "local knowledge and indigenous categories" with insight into the analysis of Taiwanese technology history, this paper intends to adopt the concept of "technology-in-use", the Actor-Network Theory (ANT), and the sociological analysis of modernity in technology. More specifically, this paper seeks to answer the following questions: how Mr. Liou's technology as well as knowledge in engineering is formed, how the heterogeneous association between human and nonhuman in the wake of innovation in green energy technology is made, how Liou's innovation can exert its influence on the negotiation of green energy legislation, and how Liou's micro hydropower system contributes to an alternative mode of globalization, that is, the localization of green energy throughout East Asia, where rice-growing paddy fields and irrigation channels dominate the landscape.

The localization of green energy, to which the micro hydropower system contributes, is characterized by the entanglements of the past and the future, the entrepreneur and the enterprise of the power company, micro innovation and macro legislation, localization and globalization. This paper hopes to envision a mode of "negotiating globalization," which is neither pro-globalization nor anti-globalization, but made possible by local technical innovation in green energy.

Keywords: actor-network theory, green energy, innovation, local knowledge, negotiating globalization, technology-in-use

1. Innovation of micro hydropower system from Taiwan's old technology

This paper focuses on the micro hydropower system (川流發電系統), made by Cheng-Shi Liou (劉正獅), a unique innovation that has not been found in any other places. Mr. Liou's local green energy invention is based on the traditional irrigation system, an infrastructure constructed all over Taiwan. Mr. Liou is an inventor and entrepreneur par excellence, native to Taiwan and born in a typical rural area, Da-bei, Yuan-lin County (雲林大埤) in 1951. The only formal education that Mr. Liou received was elementary schooling. While he does not have high achievements in terms of degree, Mr. Liou obtains and even constructs a vast amount of local knowledge.

First, following the idea of "technology-in-use,"[1] this paper does not have to be

[1] See David Edgerton, "From innovation to use: ten eclectic theses on the historiography of technology," *History and Technology* 16 (1999): 111-136, and *The Shock of the Old: technology and global history since 1900* (New York, 2007).

stuck in the ideology of "original innovation," especially "innovation-in-the-lab," when evaluating the importance of technology development in terms of production, maintenance, repairing and use. Second, the green energy innovation of the micro hydropower system is in Taiwan, and the realization of the new machine is in China. Since both Taiwan and China are not in the center of modern technoscience, the case study focuses on a special pattern of local knowledge and appropriate technology.[2] Third, adopting the actor-network theory (ANT) and the sociological analysis of modernity in technology, this paper also seeks to answer the following questions: how Mr. Liou's knowledge in engineering is formed, how the heterogeneous association between human and nonhuman is made,[3] how Liou's innovation can exert its influence on the negotiation of green energy legislation, and how Liou's micro hydropower system contributes to an alternative mode of globalization, that is, the localization of green energy throughout East Asia, where rice-growing paddy fields dominate the landscape.

As the innovator just had no formal education in science and engineering, his technical life history points out the unique location of Taiwan in the global world. To some extent, we can say that the innovator exploits local knowledge to create a new hydropower system. In the beginning he started his career by repairing clocks and watches, in 1996 he applied the technical knowledge of clock to make large system of Energy-Free Emergency Ladders, and in 2006 he invented a new kind of water wheel system to generate electricity effectively. When he developed his new machine, he had to adjust his design to the traditional irrigation channels that are popular in the countryside of Taiwan, especially where the rice fields are the major way of farming.

Meanwhile, we find that it's like a kind of appropriate technology. When E. F.

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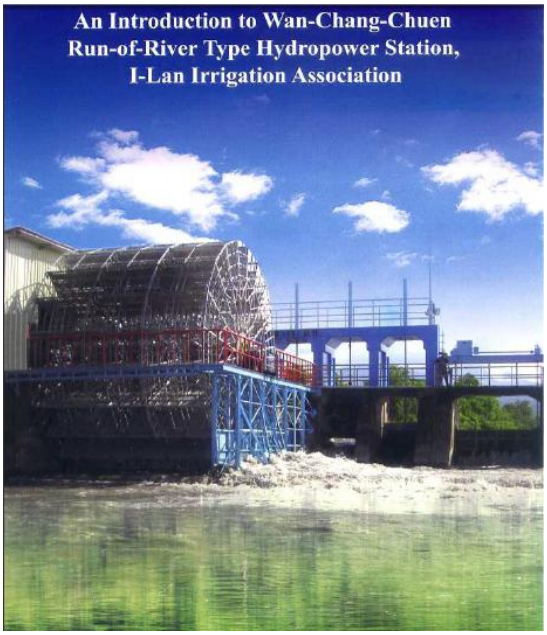
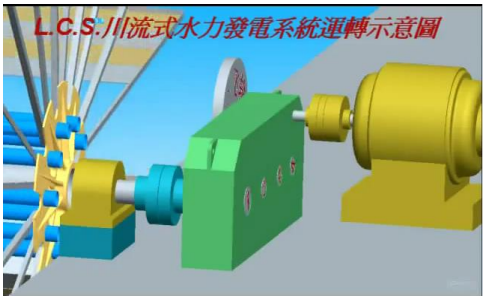
[2] See Clifford Geertz, "Local Knowledge and Its Limits: Some Obiter Dicta," *The Yale Journal of Criticism* 5(2) (1992): 129-135; Paul Stillitoe, (1998). "What, know natives? Local knowledge in development,". *Social Anthropology* 6(2) (1998): 203-220; Arun Agrawal, "Indigenous and Scientific Knowledge: Some Critical Comments," *IK Monitor* 3(3) (2004): 1-9; E. F. Schumacher, *Small Is Beautiful: Economics As If People Mattered* **(**New York, 1973); David Turnbull, *Masons, Tricksters and Cartographers: Comparative Studies in the Sociology of Scientific and Indigenous Knowledge* (Amsterdam, 2000).

[3] See Michel Callon, "Society in the Making: The Study of Technology as a Tool for Sociological Analysis," In Bijker, Wiebe E. ,Thomas P. Hughes and Trevor J. Pinch, eds., *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology* (Cambridge, Mass., 1989), 83-103; Michel Callon, "Some Elements of a Sociology of Translation: Domestication of the Scallops and the Fishermen of St. Brieuc Bay," In Mario Biagioli, ed., *The Science Studies Reader* (New York and London, 1987), 67-83; Bruno Latour, *Science in Action: How to Follow Scientists and Engineers through Society*, (Milton Keynes, 1987); Bruno Latour, 1991, "Technology is Society Made Durable," In John Law ed.. *A Sociology of Monsters: Essays on Power, Technology and Domination* (London and New York, 1991), 103-131; John Law, ed., *Power, Action, and Belief: A New Sociology of Knowledge?* (London, 1986); John Law, ed., A Sociology of Monsters: Essays on Power, Technology and Domination, (London and New York, 1991).

Schumacher suggests “small is beautiful”, he means that the available materials should be nearby, the products should be labor-intensive orientation, and the technical procedures should be easy to learn.[4] The major part of the new machine, water wheel construction, is almost made of metal bars. It weighs about 15 tons, its diameter is 8 meters and its width is 6 meters. Although it looks easy to copy, the details are more complicated. The essential details, especially the transmission system is not so easy. The machine involves a lot of special designs and the main structure is patented. In the water wheel power system, there must be an efficient gear speeding box and a lot of levers. In addition, a number of leaf blades have to be employed to control the currents of water from every direction. These key parts make the machine work well and efficiently. So, the water wheel power system is really a kind of appropriate technology, but it is never an unstable or secondary one.





2. Following the actors in the process of innovation

What are the actors in a socio-technical action? The actor-network theory (ANT) suggests an interesting way to see what these actors are. Apart from human actors, non-human actors also matter. If we want to describe and analyze an artifact, we should show the process how humans and nonhumans work together to forge a stable alliance. When positive forces emerge to make heterogeneous actors work together, we also need to notice whether there are some negative forces to separate them.

[4] See E. F. Schumacher, *Small Is Beautiful: Economics As If People Mattered* **(**New York, 1973).

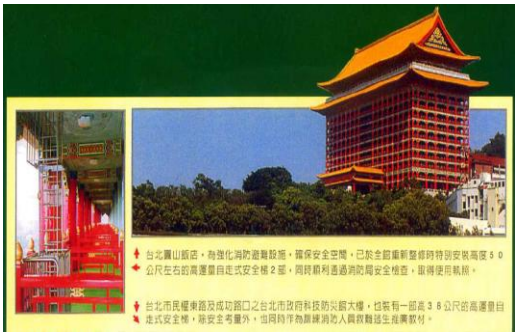
In ANT, to follow the actors means to see an artifact in an “unreal” way. If some humans or some nonhumans do not appear and interweave with each other in a certain situation, then the final association cannot be stable. Also, if the force of “anti-program” is too strong, the “program” will be unstable and the artifact won’t be real.[5]

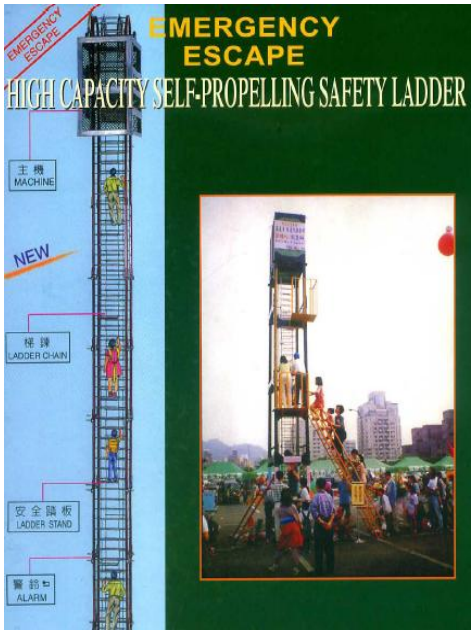
Thus, in the process of forming an alliance, how to translate other actors’ interests become crucial. However, since Mr. Liou doesn’t have any engineering degree or any laboratory, he cannot easily persuade the other human or nonhuman to engage in his network. As an entrepreneur of small-scale company, Mr. Liou gets his technical knowledge by doing. So, the best way to persuade others and to translate their interests is to show the stable machine. We find that those who do not have scientific or engineering “texts” have to make a visible and workable “black box” at first.

Mr. Liou was born in a typical rural area in Taiwan. When he graduated from elementary school, he had to earn his living in a clock-repairing shop. He didn’t have the opportunity to receive more education in his youth, but he learned so much in the practical field instead. He learned by doing in the process of repairing clocks. When he was 23 years old, he started his own company to produce alarm clocks and watches. During this period he was gradually savvy about gear and lever design, and he also knew much about metal materials and alloy stuff. When he was 38 years old, he was recommended and awarded to be one of Ten Outstanding Young Persons for his self-learning and manufacturing achievement. Then he tried to apply the technical rule of Grandfather Clocks to the brand new industrial system.

First, the Energy-Free Emergency Ladder System (高運量自走式逃生梯) was coming out in 1994; though much larger, it was just like the metal chain in Grandfather Clocks, and it could be started just by the weight of a normal person. Just like the pulled copper bar can drive the clock steadily and slowly, the weight of a person can also drive the emergency ladder system as such. When the ladder is started by the weight of any person, the weight simultaneously starts the wind resistance to slow down the landing speed. Yes, his idea works, and the first system is set up at the most famous resort in Taiwan, Taipei Grand Hotel (圓山大飯店).

[5] See Note 7.





Exploiting similar technical rules, Mr. Liou tried to substitute the weight of water for the weight of persons to start the generator system. In the hilly county in Fujian, China (中國福建), he invented the Weight-driven Power System (高落差重力式水力發電系統) and got patents of many Asian countries and Australia. Then he came back to Taiwan to find a suitable site to test the system. Although the geographical condition of some places is suitable, the system cannot work because of many environmental concerns. Mr. Liou had to find new ways to ally the other nonhuman actors.

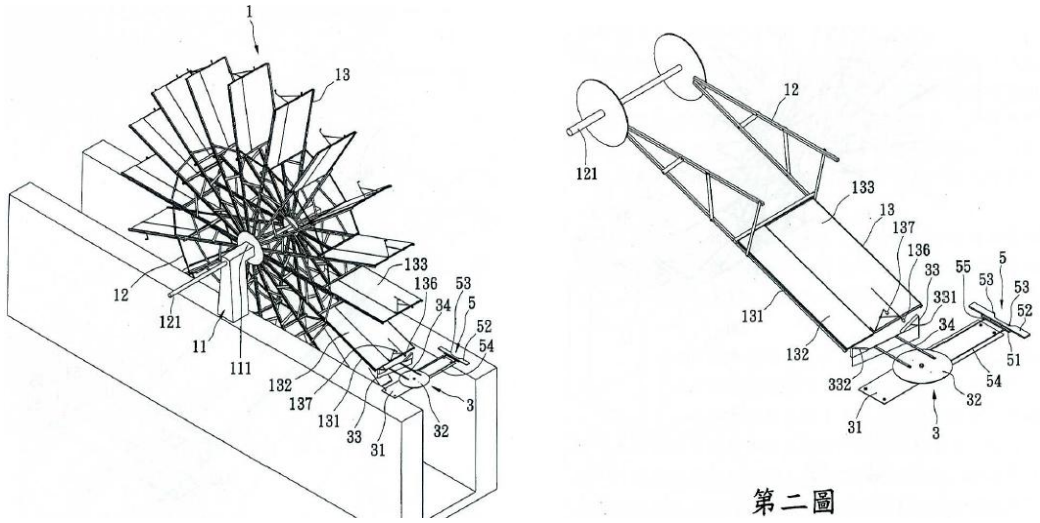
Finally, Mr. Liou noticed the irrigation system all over Taiwan's farming fields. Observing and understanding water flows in the channels, he tried to invent anther electricity generation system, the micro hydropower system without storing water or building dams. At that moment the water wheel power generation system emerged.

As we have mentioned, the innovator of the water wheel power generation system doesn't have any engineering degree or any laboratory. If he wants to translate the others' interests, he should perform his stable machine at first. Again, "learning by doing" means that Mr. Liou cannot systematically get test data or operational data just like standard engineering practices in any laboratory or workshop.

Because there are few laboratory texts to say something certain for the local innovator, Mr. Liou must make his new innovation real by recruiting more humans and nonhumans. In the beginning, Mr. Liou invited a retired vice minister of Council of Agriculture (農委會副主委) Mr. Lin to visit the test site in Fujian, China, to see the

Weight-driven Power System. Mr. Liou and Mr. Lin are both members of Ten Outstanding Young Persons, but Mr. Lin was awarded the prize before Mr. Liou. After observing the machine in Fujian, Mr. Lin wants him to find a suitable place in Taiwan for the installation of the new machine. They look for it all over Taiwan, and then a new idea burst out. Why not utilize water flows in the irrigation channels to produce electricity? In this stage, irrigation channels become the leading role of the innovation. Without any laboratory, Mr. Liou must install his design on the irrigation channel immediately. Using and improving the same technical rules of gear and lever design in Grandfather Clocks, he designs a hydraulic turbine like a water wheel which can obtain the energy from the water flows more efficiently and correct the metal leaf blades' direction according to the condition of flows. In Addition, he designs a new gearbox to speed the revolution per minute (RPM). In this way, Mr. Liou can utilize the channel water flows much efficiently; if the slope ratio of any waterway can just reach 3/1000, the machine can work.

Through the new alliance of humans and nonhumans, there is a new artifact or a new technical system coming out. The speeding gearbox can run at 750 RPM and the water wheel power generation system can produce 40 - 100 kilowatts every hour. In 2006, Mr. Liou applied for a new patent named "the Controllable Driving System and Method" (可控制之傳動系統與方法) in Taiwan, China, Japan, other Asian countries and Australia.



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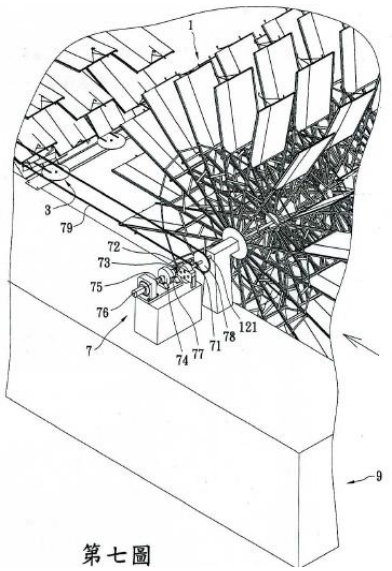


第七圖

But, when the program is speeding, the anti-program also begins. In the end, the machine was set up and ran in the channel for one and a half years, but the contract between the innovator and the local irrigation association could not work out. They have been negotiating with each other till now. Maybe we can say that it's a successful innovation, but the final translation with the humans is failed in Taiwan. The leaders of the local irrigation association do not want to bear the risk of operation, they ask the innovator to run the power station himself and take all kinds of risks. Certainly, it is costly for any small and medium-sized enterprise.

As we know, Mr. Liou and his micro hydropower system are looking for new connections of humans and nonhumans in Beijing (北京), Guangzhou (廣州) and Guangxi (廣西), China now.

3. Local knowledge derived from technology-in-use

Although the innovator of micro hydropower system in Taiwan cannot make his alliance of humans and nonhumans more stable, he indeed proposes a technical innovation of green energy. The technical story attracts us very much. How can he innovate it? How can an industrial latecomer country support its citizen to make a successful innovation? What are the meanings of this kind of green energy innovation?

We find that "self-learning" or "learning by doing" means there are some useful ways for certain human actors to obtain and improve their technical knowledge. In some measure, we can call it local knowledge, and by using local knowledge in certain society, these technical actors can make the innovation of appropriate

technology real.

Mr. Liou is still the best example to show the meanings of local knowledge and appropriate technology in the industrial latecomer countries. As David Turnbull points out, the craftsmen without modern scientific and engineering training can build the cathedrals generation by generation, because they can use "talks, templates and traditions" to transmit and improve their techniques.[6] In this sense, Mr. Liou is just like the craftsmen without modern engineering backgrounds. Turnbull suggests that by analyzing case studies of local knowledge, we can recognize the nature of scientific and engineering knowledge. To some extent, every kind of knowledge is the knowledge assembled. The assemblage of knowledge extends to the assemblage of power relations. Where there is certain power to assemble what people know or practice and make people believe it is the only and the most perfect knowledge, the effect of assemblage emerges. On the other hand, we can say every kind of knowledge is equal since all are assembled.

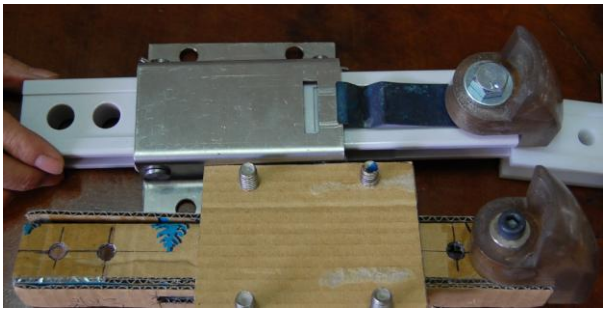
We can describe the property of Mr. Liou's local knowledge in this way: without formal engineering degree, Mr. Liou starts his learning from the practical field, Grandfather Clocks repairing and imitating. When Mr. Liou was 23 years old, he started his own company. There were 5 sub-factories in the company, including punching press, plastics injection, mold design and plastic molding production, electronic design, and trade department. In 1989, when Mr. Liou was 38 years old, the members of the company amounted to 315, and the monthly sales volume exceeded a hundred million N.T. dollars (about 3 million U.S. dollars). Mr. Liou said that he would not purchase ready-made components from the other contractors; instead, he built the necessary factories under the control of the company. During this period, he pushed himself to know and learn every detail in the factories. Eventually, he was skilled at every manufacturing procedure of Grandfather Clocks and electronic alarm clocks.

[6] See David Turnbull, *Masons, Tricksters and Cartographers: Comparative Studies in the Sociology of Scientific and Indigenous Knowledge* (Amsterdam, 2000).



In our interview, Mr. Liou said: ***"I'm better than the other innovators, because I have much more practical sense. I know every procedure of manufacturing, and I know how to cost down the materials while still maintaining the necessary strength." (2010/01/27)*** Obviously, Mr. Liou knows what he has and the others don't have. Embedded in the process of industrialization in Taiwan, Mr. Liou benefits from the global division of labor and the process of technology transfer. By processing and producing the components of clocks and watches for foreign enterprises, he learned so much. He learned how to disassemble and repair Grandfather Clocks; he also learned how to design or imitate the clock movements and cost down the materials. Further, he not only copied the original design, but also familiarized himself with the rule of gears, chains, and levers design. He tried to appropriate the rule to make large machines. It is not just to apply the rule; it takes much more imagination to improve the design. Mr. Lion said: ***"Those who are skilled at precision machinery don't know how to master heavy industry design, and vise versa." (2010/02/23)*** That is, there were clock-repairing craftsmen all over Taiwan, but very few could cross the established boundary to think on a larger scale. As he had also built the technology support network of many kinds of craftsmen during the alarm clocks production period, he dared to conceive of new and heavy artifacts. He focuses his innovation on the mechanical rather than the electronic. Using mechanical methods means offering more opportunities to the layperson participating in the manufacturing process. If the artifact could be designed by mechanical rule and run by natural dynamics, it would be the best one. Thus, he often tried to make some models by used paper boxes, and then asked the metal factories to forge the same one. It is really a kind of grass-root R&D. And, as Steven Marglin suggests that although the property of knowledge in the farms is not the same with what in scientific laboratories, yet every farm should be a

unique laboratory where farming masters could create and pass their specific practical knowledge to the next generation.[7] It is somewhat like the bricolage process of skilled craftsmen.[8] As we see, Mr. Liou doesn't have his laboratory, but he always starts his experiments in the practical field.



Back to the ideal type of appropriate technology (AT), Schumacher claims that small is beautiful; if the artifacts are made of materials nearby, labor-intensive, cheap, and easy to learn, they will be appropriate technologies.[9] But, as the experiences of 1970s in America showed, people would give up these AT artifacts, because they were not easy to use and not durable at all. So, it's the point, if the AT artifacts are not stable enough, very few people will choose them. The trend of AT lasted for just about 10 years, and then it submerged into the counter-culture or subculture.[10]

We need to revise the flaws of appropriate technology, in order to overcome the problem of durability; in this light, the concepts of alliance and stability of humans and nonhumans are workable. That is, we can use ANT to revise AT, simultaneously assemble the concept of local knowledge, technology-in-use, and the new analytic framework.

In this way, we find the case of Mr. Liou's innovation of green energy system in Taiwan is one of the best cases to show the meanings of what appropriate technology should be.

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[7] See Stephen A. Marglin, "Farms, Seedsmen, and Scientists: Systems of Agriculture and Systems of Knowledge," In Frederique Apffel-Marglin and Stephen Margli, eds., *Decolonizing Knowledge: From Development to Dialog* (Oxford; New York: 1996),185-248.

[8] See Claude Levi-Strauss, *The Savage Mind* (Chicago, 1966).

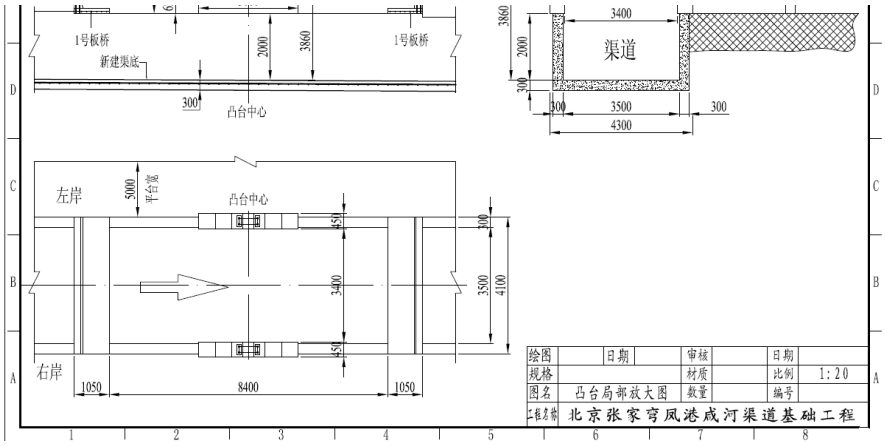
[9] See Note 7.

[10] See Langdon Winner, "Building the Better Mousetrap," In *The Whale and the Reactor* (Chicago and London, 1986), 61-84.

4. Realization of micro hydropower system in China's new energy field

Although the irrigation institutions and power generation markets in Taiwan do not accept the innovation of micro hydropower system, the news of the innovation catches the attention of the officials and businessmen in China. As the hugest processing factory of the world, China must find new ways to reduce the amount of carbon emissions. At the conference in Copenhagen 2009, China's government promised to make plans for new industries of low carbon emissions. Besides the technology transfer of the solar panels and wind power systems from the advanced countries, China also wants to search for innovations in hydropower systems.

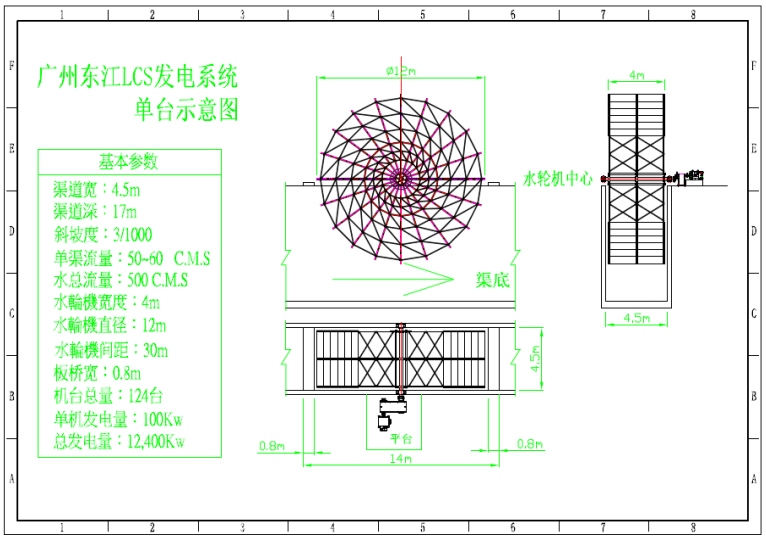
Mr. Liou's hydropower machine exactly answers what they need. During the period when his machine operated and performed in the irrigation channel in Yilan, Taiwan (臺灣宜蘭), the businessmen from China confirmed that the new innovation is able to work. A lot of companies tried to invite Mr. Liou to visit the suitable sites in every Province. After investigating for almost one year, Mr. Liou decided that the first demonstrating station should be in Guangzhou (廣州), Guangxi (廣西), or Beijing (北京).



There are different reasons for setting up the micro hydropower machines in Guangzhou , Guangxi and Beijing.

In Guangzhou or Guangxi, there is abundance of water in the channels throughout the year. It is definitely suitable. But in Beijing, there is not much water in the channels during the summer season, and what is more, usually there is drought during the winter season. In terms of technical concerns, Beijing will not be the good choice; but for the political reason, Beijing can make many things come true. Since the beginning of 2010, the important member of Chinese Energy Conservation Association (中國節能協會) has invited Mr. Liou to stay in Beijing, and they

negotiate with each other about the possibility of starting a new company to manufacture the micro hydropower machines and run the power stations. Eventually, the company was registered in December 2010, and Mr. Liou began to draw engineering designs for 100kw micro hydropower machines and for civil engineering constructions. If the consensus is achieved, there will be 124 micro hydropower machines in suburban Guangzhou, and 24 machines in the suburban Beijing.



My fieldworks and interviews are still continuing, and the analytic framework demands more consideration. I find that although the innovation of micro hydropower systems is the same, in different contexts, such as different nation-states, markets and societies, the result will not be the same.[11] In Taiwan, Council of Agriculture (農委會), the government authority, still encourages the laboratories in some universities to experiment with much smaller micro hydropower machines, at about 3kw efficiency. On the other hand, the government authority dose not appreciate the 100kw ones, the officials are concerned that this kind of machine will affect the normal water flows, and, what is more, they will not found new organizations to manage the new power systems. On the contrary, in China, the official institution of the new energy is more powerful and can make decisions more efficiently. Because China's central government asks its local governments to propose as many new plans as possible for the reduction of carbon emissions, almost all the southern Provinces are welcome the micro hydropower systems like Mr. Liou's. Not long ago, they just invited the innovator from Taiwan to be the shareholder of their company, and the innovator should offer only the technical knowledge for manufacturing, installing, maintaining and repairing the power systems. Meanwhile, China will be in charge of all the costs

[11] See Thomas P. Hughes, *Networks of Power: electrification in Western society, 1880-1930* **(**Baltimore, 1983**).**

of operation and management. In fact, between Taiwan and China, there is an important difference in the power generation market. That is, since the 1980s there have been a large number of small power stations run by the public or the private sectors all over China; however, the power generation is still centralized and there is only one power company in Taiwan. Any change of the power generation system in Taiwan must be approved by the Taiwan Power Company (台灣電力公司). For this reason, the cost of new organizations for the operation and management of power generation in Taiwan will be very huge.

The innovation of micro hydropower system is completed in Taiwan, but the innovated system on the real sites and markets can be realized only in China. Furthermore, although the power market in Taiwan cannot accept Mr. Liou's innovation right now, there are many businessmen in the Third world interested in the brand new green energy system. Till now, besides China, there have been businessmen from Southeast Asia including Indonesia and Vietnam, and from Nigeria, and Dominica, trying to get in touch with Mr. Liou. In some measure, this kind of innovation can match the social and technological condition of the Third world. If the irrigation channels can be designed to generate electricity, there will be many micro power stations all over these countries, and many village people can use green energy to live their everyday life or run their small factories.

In conclusion, with this paper, I want to answer these questions: What are the social and technological conditions with which laypersons in the latecomer countries are able to start their unique innovations? Is technology-in-use the most important mechanism? What is the implication when the micro hydropower system is innovated in Taiwan, but realized in China? Is there any fundamental difference of the constitution of nation-state, society and market between Taiwan and China? How do the governments and companies in these two countries decide the reasonable price of electricity generated by the micro hydropower system, if there are some subsidy policies to encourage new energy systems? And, in terms of technical concerns, how do the investors, engineers and laboratories in Taiwan and China test and confirm the efficiency of the micro hydropower system?

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