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Status of Direct Use of Geothermal Energy in the Philippines

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ABSTRACT

This paper attempts to highlight the nonelectrical and direct utilization of geothermal energy in the Philippines. Aside from the drying plants in Palinpinon and Manito, hotspring resorts and private pools utilizing hot water from the province of Laguna is included in this paper. In addition, the geothermal salt making pilot plant in Tiwi, Albay is mentioned in this paper although it has already been decommissioned in 1984.

The Palinpinon multicrop drying facility demonstrate the direct use of geothermal resources for agro-industrial purposes and uses low enthalpy waste from the geothermal plant of Southern Negros Geothermal Plant. On the otherhand, the Manito Lowland Drying Plant uses the low enthalpy system from the geothermal reservoir of Bacman Geothermal Field. The drying plants are designed to dehydrate agricultural and marine products to raise the quality and meet higher standards and to reduce post-harvest losses of agricultural and marine produce in the area.

Meanwhile, more than 500 hotspring resorts and pools are using natural hot water at the foot of Mt. Makiling in Laguna. Mt. Makiling also hosts the 425.73 MWe Makban Geothermal Power Plant. Commercial pools and resorts are designed for recreational and therapeutic purposes.

The salt making plant in Tiwi, Albay uses excess geothermal steam from a 2.5 KW demonstration power plant to effect the evaporation of seawater. Geothermal steam heats and boils the sea water effecting selective precipitation through evaporation and concentration.

1. INTRODUCTION

The Philippines, being situated in an island arc is endowed with vast potential of geothermal resources. At present, the Philippines is ranked second in the world in terms of geothermal installed capacity (table 1). Contribution of geothermal made possible the reduction of country's dependence on imported fuel. In 2003 alone, 19.10% (figure 1) of the country's power requirements came from geothermal generation. As such, the country is always associated with geothermal energy for electricity generation. However, in the case of nonelectrical and direct utilization of geothermal energy, the Philippines has done considerable researches on the development of geothermal energy for direct utilization since the early part of 1960. This has led to the establishment of a salt making pilot plant in Tiwi, Albay in 1972 using excess geothermal steam from a 2.5 KW geothermal demonstration power plant. Tiwi hosts the 330 MWe geothermal power plant in Albay (figure 2). However, the plant was decommissioned in 1984. Nevertheless, it was a showcase of direct utilization of geothermal energy and a result of a series of studies done on the geothermal steam's applicability.

Table 1 World Installed Geothermal Plant Capacities

Country	1990	1995	2003
USA	2274.60	2816.70	2003.00
Philippines	891.00	1191.00	1930.89
Italy	545.00	631.70	785.00
Indonesia	144.75	309.75	770.00
Mexico	700.00	753.00	755.00
Japan	214.60	413.70	544.00
New Zealand	283.20	286.00	441.00
Iceland	44.60	49.40	167.00
El Salvador	95.00	105	161.00
Costa Rica		55.00	161.00
Kenya	45.00	45.00	45.00
Russia	44.00	11.00	34.00
Guatemala			33.00
China	19.20	28.78	28.00
Nicaragua	35.00	35.00	20.00
Turkey	20.60	20.60	20.00
Portugal	3.00	5.00	16.00
Ethiopia			7.00
France	4.20	4.20	4.00
Greece	2.00	2.00	2.00
Argentina	0.67	0.67	0.70
Australia		0.17	0.40
Thailand		0.30	0.30

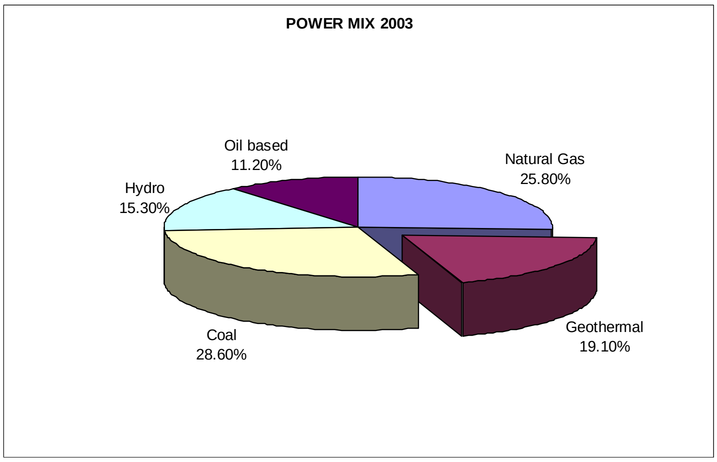

Figure 1: power mix in 2003

In 1992, an agro industrial plant in Palinpinon in Southern Negros Geothermal Production Field was established (figure 2). The plant is envisioned to demonstrate the direct use of geothermal energy for agro-industrial purposes and at the same time provides major benefits by raising the quality of the products processed and meets higher standards.

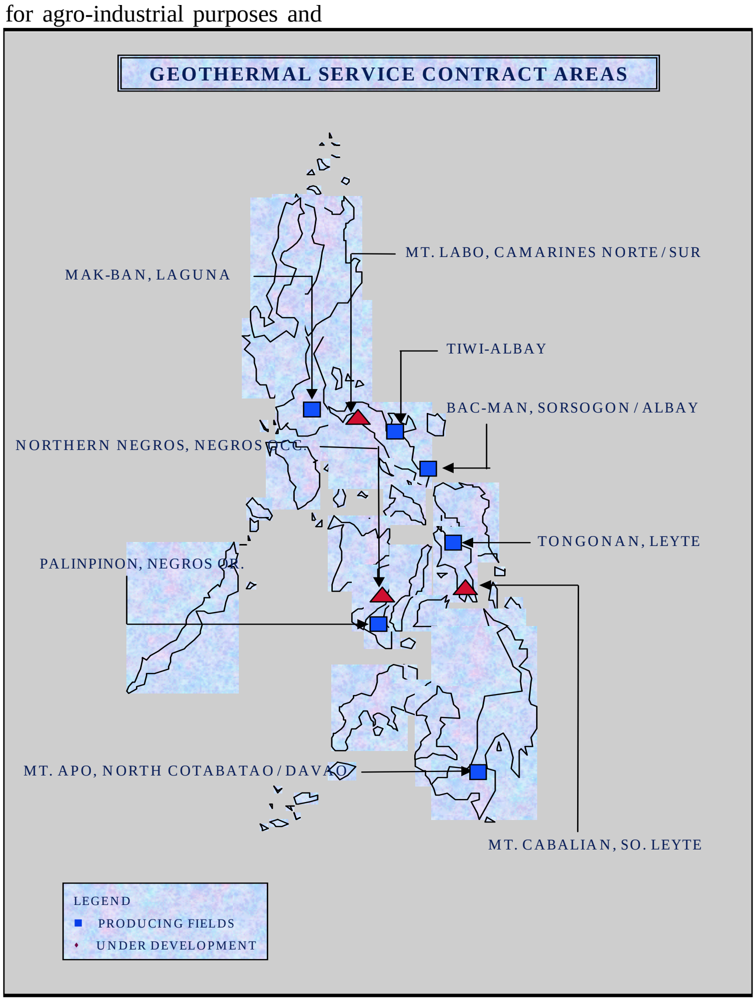

Figure 2: Geothermal service contract areas

and at the same time provides major benefits by raising the quality of the products processed and meets higher standards.

In 1998, the Department of Energy (DOE), and its attached agencies PNOC-Energy Development Corporation (PNOC-EDC), National Power Corporation (NPC) and National Electrification Administration (NEA) together with the Local Government Unit (LGU) of Manito put up a multicrop drying facility in the Manito Lowland. Manito Lowland is located at the northwest portion of Bacman Geothermal Field (figure 2). The plant aims to reduce the post harvest losses of agricultural produce in Manito and increase the value of the agricultural products through the improvement of product quality.

2. CATEGORIES OF UTILIZATION AND GEOTHERMAL ENERGY USED

The direct-use applications of geothermal energy in the Philippines are drying of agricultural and marine products, bathing and balneology and salt making. Temperature of steam being utilized ranges from 30 to 100^0C. Total installed thermal capacity is 3.30 MWt and thermal energy used is 1.25 MWt. Capacity factor stands at 0.39 while total energy used is 39.58 TJ/year (table 2).

Calculations of geothermal energy is based on the following assumptions:

Installed Thermal Capacity in MWt (P_c) = (T_i - T_o) x F_{av} x 4.186/3600

Thermal Energy Used in MWt (E_u) = P_c x (H_{av}/24) x (D /365)

Capacity Factor = E_u / P_c

Annual Energy Used (TJ/year) = E_u x 31.536

Where : T_i is inlet temperature (^{0}C)

T_o is outlet temperature (^{0}C)

F_{av} is average flow in tons/hour

H_{av} is average hours of operation a day

D is number of days of operation

Table 2 Installed Thermal Capacity

Location	Installed Thermal Capacity (MWt)	Thermal Energy Used (MWt)	Capacity Factor	Total Energy Used (TJ/year)
Palinpinon Drying Plant	1.00	0.55	0.55	17.34
Manito Drying Plant	0.63	0.30	0.48	9.59
Laguna Hot Springs	1.67	0.40	0.24	12.65
Total	3.30	1.25	0.39	39.58

3. TIWI GEOTHERMAL SALT MAKING PLANT

3.1 Historical Background

The plant is the first of its kind in the Philippines and in the world. The plant symbolizes the collective efforts of a group of Filipino technocrats, scientists and engineers in the pursuit of socio-economic progress through the utilization of geothermal energy for direct use.

In 1967, Commission of Volcanology, now known as Philippine Institute of Volcanology and Seismology (PHIVOLCS), displayed the feasibility of lighting an electric bulb using geothermal steam with the cooperation of National Science Development Board (NSDB), Bureau of Mines (BM), Provincial Government of Albay and other private and public institutions. In 1969, the 2.5 KW demonstration plant was put up. However, a large amount of excess steam is released to the atmosphere and again COMVOL made researches on the application of the steam to the industry. In 1972, the first grains of salt were crystallized in the plant using geothermal steam.

3.2 Process Description

The salt plant utilizes a three-single effect vertical tubes evaporators. Geothermal steam is introduced into the vertical radiators of the evaporators at 7 pounds per square inch (psi) pressure which brings the pre-heated sea water to vigorous boiling.

Sea water from a three-kilometer source is pumped to a 16,000 gallon concrete storage tank using an electric motor pump.

From the storage tank, seawater is transferred by gravity to a feed and filter tank utilizing several layers of sand and gravel to remove insoluble materials and impurities. Then the clear seawater is pumped to a shell and tubepreheater where the feed is preheated to about 71^0 to 76^0C before entering the evaporators.

Preheated seawater enters the evaporator in a spray pattern and heated to vigorous boiling by steam from the geothermal well until the brine reaches a density of about 10 to 15 degrees Baume to prevent the precipitation of $CaSO_4$ that causes the scales in the radiator.

The brine is then drained into settling pans and concentrated further until it reaches 24 degrees Baume where most of the calcium sulfate is precipitated together with other impurities.

The clear brine is next drained to an open type crystallizer pan. The concentrated brine is further heated by means of submerged tube which steam passes through. From 25 degrees Baume to 29.5 degrees Baume, sodium chloride (NaCl) crystallizes rapidly and settles the bottom of the pan. The salt produced at this range is of high quality (grade I salt - 97% to 98% NaCl) and above this range, impurities starts to crystallize.

The crystallized salt is drained and led to a rotary mixer-dryer heated by steam.

The dried salt with 0.5% to 1% moisture content is fed into iodizing machine for treatment with 2% KIO_3 solution so that it will contain about 0.01% KI or 100 parts per million KI. The iodized salt is taken to Quality Control Room for KI content analysis.

Dried iodized salt is bagged in one kilogram, 500-gram, 250-gram packs, labeled and sold. Salt production is about 1.4 tons per day.

3.3 Problems Encountered

- Lack of private sector participation due to high capital outlay

4. PALINPINON AGRO-INDUSTRIAL PLANT

4.1 Historical Background

PNOC-Energy Development Corporation, the leading geothermal field developer in the country undertook a series of United Nations Development Program (UNDP) assisted feasibility studies on the development of nonpower applications of geothermal energy in 1986. One of the findings and recommendations of these studies is setting up of an agro-industrial plant in Southern Negros Geothermal Production Field. In 1992, the UNDP funded the agro-industrial plant in Palinpinon where PNOC-EDC is operating one of its geothermal fields that supply steam to National Power Corporation. The objective is to operate a 1 MWt drying facility using low-enthalpy geothermal heat.

4.2 Process Description

The drying plant uses the separated brine from the Palinpinon Geothermal Plant as its source of heat. The plant is located at one of the reinjection pads of the Southern Negros Geothermal Field where the separated brine is reinjected back into the geological formation below.

The geothermal brine with a temperature of 160^0C is passed through a primary shell and tube heat exchanger where heat is extracted. The outlet temperature of the primary heat exchange is controlled to a minimum of 154^0C to avoid silica deposition in the reinjection well. This is done by controlling the flow rate of the clean water.

Clean water at 80^0C is pumped from the atmospheric hot water to the primary heat exchanger. From the primary heat exchanger, the heated water is passed through seven identical air heaters, cooled down to 80^0C and then return to the hot water tank.

4.3 Drying Plant

The drying plant is designed to handle an estimated 12 MT/day of coconut meat equivalent to about 6 to 7 MT of copra (at 7 to 10% moisture content). The operating capacity is 85 to 95% of rated capacity to ensure operational viability of the drying plant.

While the plant primarily process copra, it is designed with independent drying units capable of simultaneously handling several agricultural and marine products. More than 50% of the total available capacity is devoted to coconut meat drying.

4.4 Problems Encountered

- Silica deposition in the reinjection well due to thermal drop
- Cooperative's lack of financial capital to buy raw materials
- Low market price of the main product (copra)

4.5 Installed Thermal Power

Installed thermal capacity of Palinpinon agro-industrial plant is 1 MWt. Thermal energy used is 0.55 MWt and capacity factor is 0.55. Annual energy used is 17.34 TJ/year (table 2).

5 MANITO LOWLAND DRYING PLANT

5.1 Historical Background

As part of the techno-economic feasibility studies done on the development of geothermal energy for nonelectrical uses in 1988, Manito, Albay in Bacman Geothermal Field shows an abundance of agricultural crops and marine products in the area.

In 1998, the DOE and its attached agencies NPC, NEA, PNOC-EDC and LGU of Manito undertook a project that will utilize the geothermal steam of Bacman Geothermal Field Reservoir in increasing the value of their agricultural and marine products. It also aims to reduce the post harvest losses in the locality. The project is a multi-crop drying facility using geothermal steam.

The drying plant commenced operation at the same time with the 1.5 MWe power plant. Materials dried were limited to agricultural and marine products like copra, cassava, fish, seaweed and squid. Since commissioning, the drying plant has operated intermittently depending on the availability of the materials.

5.2 Process Description

The plant has a capacity of drying 3 tons of materials per day. The steam leaving the turbine is delivered to the multi-crop drying facility. The facility is composed of two shell and tube heat exchanger, two finned-tube air heater, two centrifugal blowers, water tank and two sets of drying cabinets.

The steam leaves the backpressure turbine of 1 ksca and a temperature of 100^0C. The water is then heated through shell and tube heat exchangers with a total estimated heat duty of 125 kW. About 5 kg/sec of fresh water is heated from 70^0C to 80^0C. Steam passes through the shell side of the heat exchanger while the water is on the tube side. Freshwater cycle is a close loop cycle with provisions for make up due to evaporation and leakage loss. The heated water is piped to the finned-tube heaters to heat the atmospheric air that will be blown by the centrifugal blowers. The heated air is blown from the bottom of the tray dryer and as it passes through the raw materials, the air absorbs the moisture from the material and the dehumidified air is ducted at the top of the dryer. The cycle continues until the desired dryness of the material is achieved.

The facility is capable of drying 3 tons of copra per day. The final moisture content of the dried product is between 6 to 10% moisture for a drying time of 16 to 20 hours.

5.3 Problems Encountered

- Calcite deposition in the production well
- Silica deposition in the reinjection well

5.4 Installed Thermal Power

Total estimated installed thermal capacity in Manito is 0.63 MWt. Thermal energy used is at 0.34 MWt. Capacity factor is 0.48 while total energy used is 9.59 TJ/year (table 2).

6. HOTSPRINGS AND RESORTS IN LAGUNA

6.1 Historical Background

Long before the establishment of geothermal plants in the country, hot spring resorts and pools utilizing hot natural water from the foot of Mt. Makiling already abound in Laguna. Hot natural water is already being utilized for bathing, swimming and balneology purposes in the area. Little it has been known during that time that these resorts are already using geothermal energy directly. At present, in the town of Los Baños and city of Calamba, more than 500 resorts, both private and public, are drawing hot water from the foot of Mt. Makiling. Mt. Makiling hosts the 425.73 MWe Makban Geothermal Field. Unfortunately, due to time limitation and budgetary constraints, only 66 hotspring resorts out of more than 500 resorts in the aforementioned areas were surveyed.

6.2 Utilization

The hot spring resorts in Laguna are open twenty-four hours a day. During summer months of March to May, these resorts are fully booked and occupied daily. However, as summer months passed local tourists come only on weekends.

Swimming, bathing and balneology are the direct use of geothermal energy in Laguna. The waters are promoted for skin troubles, relaxation, therapy and recreation. Individuals come to the area for recreation and therapeutic purposes. With the location's proximity to the capital city of the Philippines, most of the resort's guests and patrons are from Manila and residents of nearby towns and provinces.

The reservoir of hot water is usually exploited using conventional water well drilling/pumping system. Most of these resorts pump the water below but there are few resorts where hot water flows freely. Pump capacity of these resorts ranges from 1 to 7.5 HP. Average pool size is 10 m x 6 m x 1.5 m. Water replacement is done once or twice a week. Other resorts do the water replacement daily depending on the clarity and condition of the water. Others treat the water with chlorine to improve the clarity and minimize replacement. Others put $CuSO_4$ to make the water appearance bluish.

6.3 Installed Thermal Power

Total flow of hotsprings is estimated at 63.7 liter/second. Most of these resorts use low temperature water between 37 to 50^0C. Installed thermal power is estimated to be 1.67 MWt and annual energy used is 12.65 TJ/year. Capacity factor is 0.40 (table 2).

7. CONCLUSION

Harnessing of direct application of geothermal energy in the Philippines has gone a long way. The various studies conducted on the direct application of geothermal energy done by Filipino technocrats, scientist and engineers has led to its commercial development. The development of geothermal resources for direct utilization further increases the country's energy self-sufficiency. Moreover, economic activities in the areas hosting the untapped resources are stimulated resulting in the improvement of quality of life in the area. Although these direct applications were put into commercial operation, others were discontinued and operated intermittently for various reasons. The salt making plant in Tiwi was operated in 1972 to 1984 where one ton per day of high-grade salt plant was put into operation. The Palinpinon agro-industrial drying plant was put up in 1992 and operated by PNOC-EDC until 1997. Then it was turned over to a local farming cooperative to operate and manage. However, due to lack of financial resources, low market price of the main product and deterioration of the plant, the drying plant has ceased operation in 2001. The Manito drying plant, which was commissioned in 1998, has not been fully utilized since its commissioning. It has operated intermittently due to its dependence on the power plant operations and the unavailability of raw materials in the area.

8. FUTURE PLANS AND PROGRAMS

With the extensive exploitation of the economically viable, high-enthalpy geothermal resources and the fact that most of the remaining geothermal prospects of the country are of the intermediate to low-enthalpy types, the Government now gears for the development of small-scale geothermal resources for direct utilization. This is in line with the government policy, which is poverty alleviation in remote and off-grid areas. Therefore, the Department of Energy, (DOE) thru its Geothermal Division of the Energy Resource Development Bureau (GD-ERDB), is currently focused on promoting the development of the untapped small-scale geothermal resources for direct utilization. The DOE is currently drafting a guidelines for nonelectrical utilization of geothermal energy in order to accelerate the nonelectrical utilization of the country's geothermal resources.

At present, there are two geothermal direct utilization project proposals submitted to Japan International Cooperating Agency (JICA), namely, Tongonan Multi-

Crop Drying Plant in Leyte and Mambucal Multi-Crop Drying Plant in Northern Negros.

In addition, the Department of Tourism (DOT), DOE and Philippine Institute on Traditional Health and Alternative Health Care (PITAHC) of the Department of Health (DOH) signed a Memorandum of Agreement (MOA) for the promotion of Philippine Hot Springs for Resort Development Project. The project undertaking aims to promote health tourism by encouraging spa resort development within appropriate hot spring locations nationwide (figure 3).

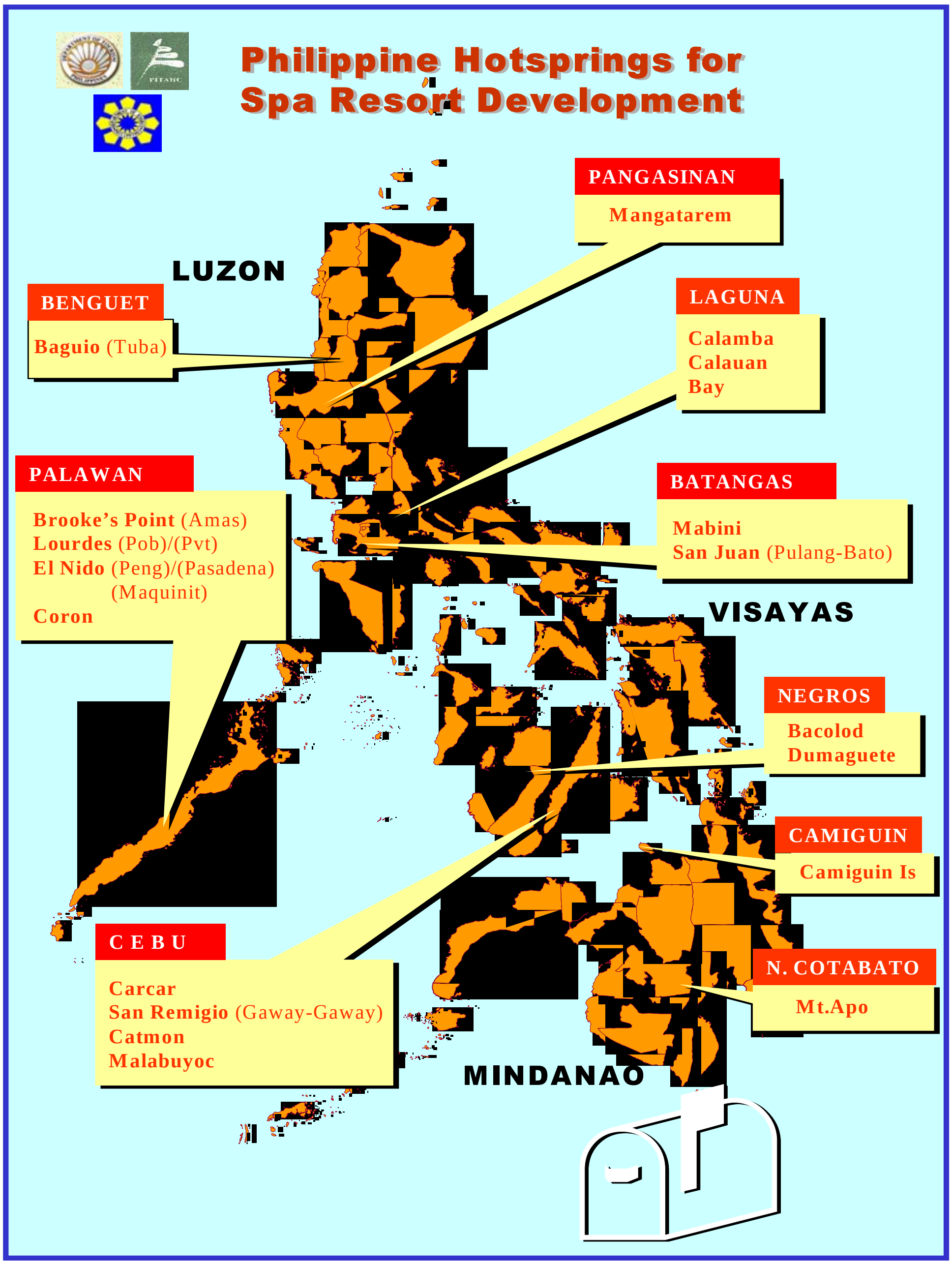

Figure 3: Spa resort development

For future geothermal direct utilization projects, socio-economic profiling of geothermal prospect areas hosting the untapped geothermal resources is now being undertaken.

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