CHAPTER 15

Electricity reforms and its impact on groundwater use: Evidence from India

Aditi Mukherji
International Water Management Institute (IWMI), Colombo, Sri Lanka

Tushaar Shah
International Water Management Institute (IWMI), Anand, India

Shilp Verma
UNESCO-IHE, Delft, the Netherlands

ABSTRACT: Minimizing the negative impacts of groundwater over-exploitation, while preserving the benefits from such intensive use has emerged as the key natural resources management challenge in South Asia. Direct regulation of groundwater is not a feasible option in the region given over 20 million pumps and the huge transactions costs involved. In this context, indirect mechanism, such as regulation of electricity supply and changes in electricity pricing and subsidies can provide an effective tool for governing groundwater. This chapter documents two such cases of electricity reforms that have had profound impact on groundwater use in Indian states of Gujarat and West Bengal.

Keywords: groundwater, electricity, reforms, subsidies, Gujarat, West Bengal

1 INTRODUCTION

The electricity and groundwater sector in India is intricately linked by the fact that over 50% of pumps and tubewells in the country are electrically operated and electricity pricing affects farmers pumping behavior. Until the early 1970s, all state electricity boards (SEBs) charged their tubewell owners based on metered consumption and this was later changed to flat tariff in the 1980s, mostly on account of ease of administering flat tariff. The original intention was to keep increasing this flat tariff to reflect increase in cost of electricity generation. However, over time flat tariff rates became tool of political appeasement and remained perpetually low. The SEBs started making huge losses, both on account of low recovery from agriculture, but also due to their own inefficiencies. Low flat tariffs also led to over-exploitation of groundwater in arid and semi-arid states of India. Therefore, recently, there is a renewed interest in reforming the electricity sector and this has profound implications on the groundwater sector.

Given both water resources and electricity are state subjects in India, individual states have chosen to go about differently *vis-à-vis* power sector reforms, keeping in mind the political exigencies faced by these states. The state of West Bengal in the east has embarked upon a path of universal metering of agricultural electricity consumers, mainly because there are no strong farm lobbies in the state to oppose such a move. This shift from flat rate tariff (signifying zero marginal cost of pumping) to pro-rata tariff, altered the cost and incentive structure of the pump owners and hence affected their pumping behavior. On the other hand, the Government of Gujarat, in face of strident farmer opposition, decided not to meter tubewells, but instead separated agricultural feeders from non agricultural ones. They also improved the quality of power supply and rationed the number of hours of electricity to agriculture for only 8 hours in a day, thereby influencing farmer pumping behavior. This initiative of the Government of Gujarat is called the *Jyotirgram Yojana*.

The purpose of this chapter is to document the reforms and present a first cut analysis of the impact of these reforms on the pumping behavior of pump owners, on the informal groundwater markets through which water buyers would be impacted. The chapter is divided into five sections. After the first introductory section, the second section describes the groundwater and electricity situation in the two states. The third section discusses the process and implementation of the power sector reforms in each of these states, while the fourth section analyses the impact of these on groundwater use and on groundwater markets. The final section presents the conclusions and policy implications of this study.

2 GROUNDWATER AND ELECTRICITY SITUATION IN WEST BENGAL AND GUJARAT

West Bengal, an eastern state of India receives an annual rainfall of around 2,000 mm and has a groundwater potential of 31,000 Mm^3, most of which is available at shallow depths. Only 42% of the total available groundwater resources in the state has been utilized so far (WIDD, 2004). While West Bengal has plentiful groundwater resources that can be furthered developed, the state has for various political reasons (Mukherji, 2006) adopted one of the most stringent groundwater regulations in India. For instance, procuring electricity connection for tubewells needs permission from multiples sources, such as the State Water Investigation Directorate (SWID), village level bodies (*panchayats*), and the process is fraught with red-tape and corruption. The result is that West Bengal has the lowest proportion of electric tubewells to total tubewells in India (GOI, 2003). The farmers in West Bengal, till 2007, also paid the highest flat tariff (Rs. 2,160/HP/yr) [US$ 48/HP/yr][1] for electricity among all Indian states. Agricultural consumption of electricity accounted for only 6.1% of total electricity consumption (WBSEB, 2006), and unlike other states where electricity subsidy forms a major share of state fiscal deficits, in West Bengal this was negligible (Briscoe, 2005). Existence of very high flat tariff, coupled with small sized land holdings and abundant groundwater resources had led to the emergence of competitive informal groundwater markets, and small and marginal water buying farmers benefitted substantially through these markets. The main irrigated crop is the summer paddy, called *boro paddy*. Average annual pumping hour varies from 1,500 hours to 2,100 hours for centrifugal and submersible pumps respectively.

Gujarat, a western state of India, receives an average annual rainfall of 1,243 mm, though with wide regional variations. South Gujarat receives the bulk of the rainfall, while western parts of the states (Saurashtra and Kutch) are distinctly arid. The state has an annual replenishable groundwater potential of 15,810 Mm^3 of which 76% (11,490 Mm^3) is withdrawn every year. This is a state where groundwater is used intensively and 61% of the administrative blocks are over-exploited, critical or semi-critical as per the norms of the Central Groundwater Board (CGWB) [http://cgwb.gov.in/gw_profiles/st_Gujarat.htm]. North Gujarat, which on an average receives 500–700 mm/yr of rainfall, has deep alluvial aquifers and is a basket case of unsustainable use of groundwater. In many ways, the state of Gujarat epitomizes the groundwater crisis in India. Yet, the state has been registering an agricultural growth rate of 10% for the last 7–8 years and this surpasses that of other states better endowed with water resources (Gulati *et al*., 2009). Here, farmers have also increasingly moved away from cereal crops to high value crops, such as Bt cotton, tobacco, dairy, orchard and commercial crops, so as to maximize value per drop of water. Gujarat also has strong farmer lobbies that have time and again successfully thwarted any attempt to curtail their access to groundwater (Mukherji, 2006). Gujarat, till the recent reforms, had one of the highest electricity subsidies in India. Given the heavy losses sustained by the state electricity board, there was a rapid deterioration of the quality of power supply in the state thereby negatively affecting the quality of life in rural areas. Gujarat, like West Bengal, also supports a vibrant groundwater market. Indeed, groundwater markets in Gujarat predate that of other regions in India (Shah, 1993). Figure 1 shows the location of these two states.

[1] 1 Rs (Indian Rupees) = 0.0221813 US$ (2010, May, 11th).

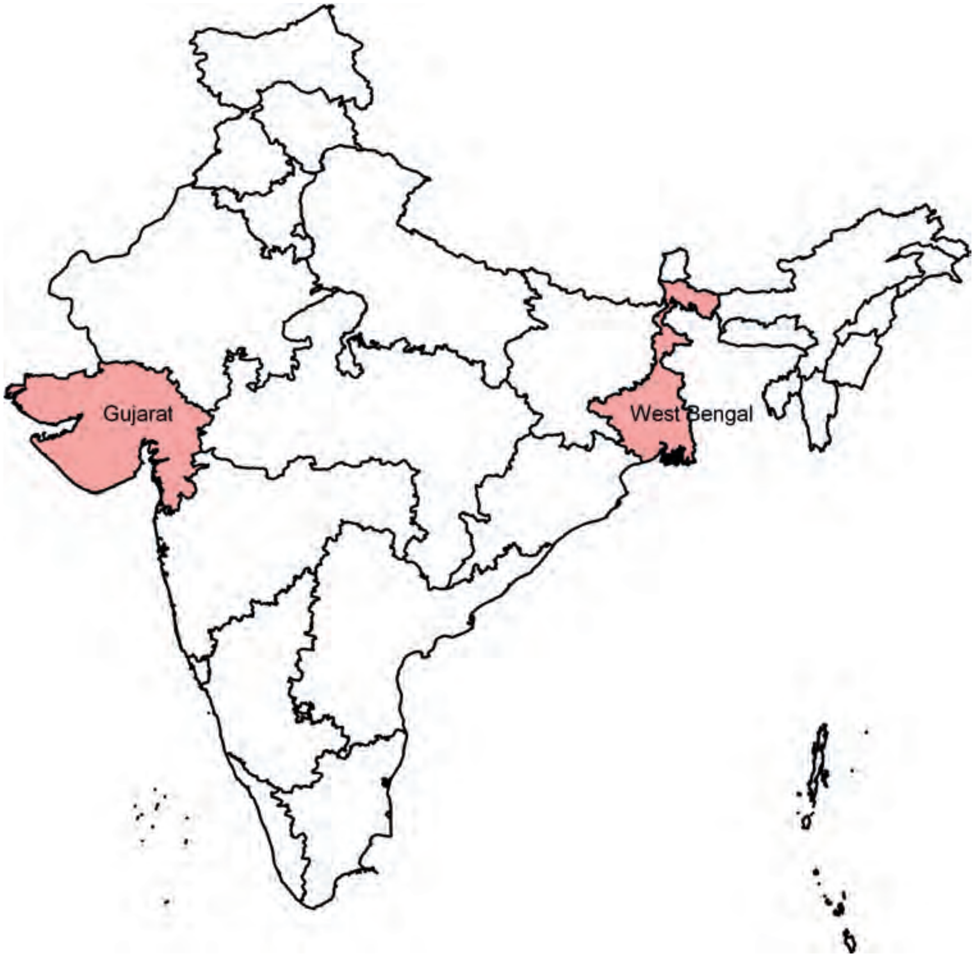

Figure 1. Location of study states.

3 THE PROCESS OF ELECTRICITY SECTOR REFORMS IN WEST BENGAL AND GUJARAT

3.1 *Metering in West Bengal*

The Government of West Bengal (GoWB) has adopted a hi-tech approach to metering through the installation of remotely sensed tamper-proof meters which operate on the *Time of the Day* (TOD) principle. TOD is a demand management tool whereby, by differentiating the cost of electricity during different times of the day, consumers are discouraged from using pumps during peak evening hours while they are encouraged to do the same during slack night hours. There are three metered tariff rates, namely, normal rates from 6 a.m. to 5 p.m. (Rs. 1.37/kW·h) [US$ 0.03/kW·h][1], peak rates from 5 p.m. to 11 p.m. (Rs. 4.75/kW·h) [US$ 0.11/kW·h][1] and off-peak rates from 11 p.m. to 6 a.m. (Rs. 0.75/kW·h) [less than US$ 0.02/kW·h][1]. On average these unit rates translates to around Rs. 6/hour [US$ 0.13/hour][1] inclusive of Rs. 22/month [US$ 0.49/month][1] as meter rent. The new meters use GIS and GSM technologies and are remotely read (Figure 2). These new meters solve many of the traditional problems of metering, namely, tampering, under-reporting

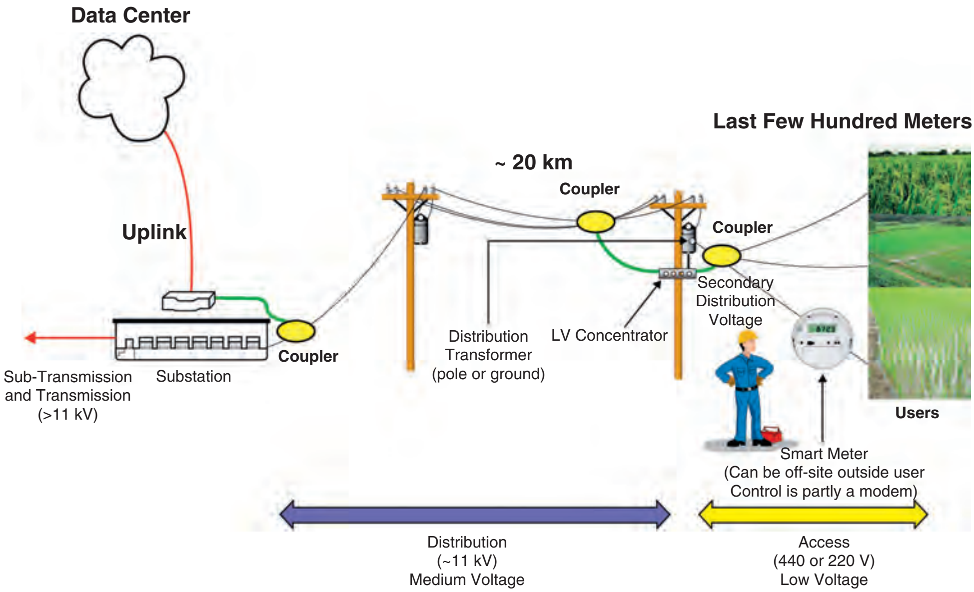

Figure 2. A schematic diagram of a generic IT Power Distribution System that is being used in West Bengal (adapted from Tongia, 2004).

and under-billing by the meter readers in collusion with the villagers, arbitrary power of the meter readers and the physical abuse that the meter readers were subject to at times at the hands of the irate villagers. Meters are now remotely read and reading is transmitted directly to the commercial office. The meter reader neither knows, nor can tamper with the meter reading.

3.2 *Jyotirgram Yojana in Gujarat*

In September 2003, the Government of Gujarat (GoG) pioneered a bold scheme –the *Jyotirgram Scheme* (JGS)– to separate agricultural feeders from non-agricultural ones. JGS was launched initially in 8 districts of Gujarat on pilot basis. The early results were so encouraging that by 2004, the scheme was extended to the entire state. By 2006, over 90% of Gujarat's 18,000 villages were covered under JGS. This involved total rewiring of rural Gujarat. 48,852 km of high tension lines and 7,119 km of low tension wires were added. 12,621 new transformer centres were installed. 1.2 million new electricity poles were used. 1,470 specially designed transformers were installed. 182,000 km of electricity conductors and 610,000 km of low tension PVC cables were used. 30,000 tonnes [1 tonne = 1,000 kg] of steel products were used. In short, under the JGS, the Gujarat Electricity Board (GEB) laid a parallel rural transmission network across the state at an investment of Rs. 11,700 million [US$ 260 million][1]. Feeders supplying agricultural connection were bifurcated from the supply to commercial and residential connection at sub-station level. Meters on distribution transformer centres were also installed on feeders to improve the accuracy for energy accounting.

Pre-JGS, at the lowest level, 11 kV feeders served a group of 2–5 villages wherein all connections in these villages (domestic, agricultural, as well as commercial) were through this feeder (see Figure 3a). Post-JGS however, the feeders were bifurcated into agricultural and non-agricultural feeders (Figure 3b). This meant that certain feeders only served farm consumers and connections, while the rest served the domestic and commercial customers. Meters were installed on each feeder, especially the agri-feeders to identify the source of any *significantly-greater-than-expected* demand at any particular feeder. Rural Gujarat thus rewired, the government put into place a new rural electricity regime that provided high quality, predictable, reliable, but *rationed* power supply

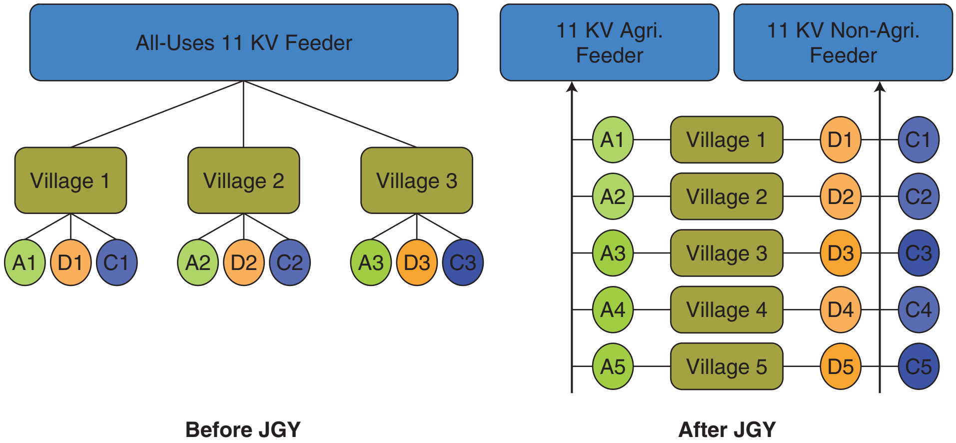

Figure 3. a) Electricity Network before JGS; b) Electricity Network after JGS.

to agriculture. Under the JGS, then: a) the villages began to be provided 24 hour power supply for domestic uses, in schools, hospitals, village industries; b) farmers began getting 8 hours of daily power supply but of full voltage and on a pre-announced schedule. Every village is to get agricultural power during the day and night in alternate weeks that are pre-announced.

4 IMPACT OF ELECTRICITY REFORMS ON GROUNDWATER USE

4.1 *Impact of metering in West Bengal*

In West Bengal, groundwater markets emerged in response to high flat rate tariff, whereby, the tubewell owners were under pressure to sell water just to recover the electricity bill given their own land holding was not sufficiently large to justify the high electricity cost. This compulsion on the part of tubewell owners also meant that water buyers, who happen to be mostly small and marginal farmers, had sufficient bargaining power over the water seller. That this reasoning is correct is shown by the fact while flat tariff rates increased around 10 fold from 1991 to 2006 (from Rs. 1,100/yr [US$ 24/yr][1] to Rs. 10,800/yr [US$ 240/yr][1]), water price only rose by 3 times from Rs. 300/acre [US$ 6.65/acre][1] [US$ 16.45/ha] in 1991 to Rs. 1,800/acre [US$ 40/acre][1] [US$ 99/ha] in 2006 for summer *boro paddy* (Mukherji, 2007). However, metering of electricity supply has changed the very incentive structure and now the water sellers are no longer under a compulsion to sell water, because they will pay only for as much as they pump. So, soon after metering, the pump owners have increased the rates at which they sell water by 30–50%, even though, assuming same hours of usage as under earlier flat tariff, we found that they would have to pay a lower electricity bill under metered tariff than before. The pump owners have therefore benefitted under the current meter tariff regime in two ways: a) by having to pay a lower electricity bill than before, for same hours of use; b) by being able to charge a higher water price than before and therefore increasing their profit margins for selling water. It has to be noted that there are only 100,000 or so electric pump owners in the state and they constitute less than 2% of the total farming households. It is this small group of relatively wealthier farmers who have benefitted directly from metering. On the other hand, the water buyers have lost out in two ways too: a) by having to pay a higher water charge than before; b) by having to face adverse terms of conditions for buying water (e.g. advance payments, not been able to get water at desired times, etc.). At the current tariff rates, and assuming same usage pattern, the SEB too will lose out in terms of revenues, but it may gain through decrease in transmission and distribution (T&D) losses. The actual impact of metering

Table 1. Impacts of the *Jyotirgram Scheme* on different stakeholder groups.

Stakeholder group	Positive (+) Negative (–)
Rural housewives, domestic users	+ + + + + +
Students, teachers, patients, doctors	+ + + + + +
Non-farm trades, shops, cottage industries, rice mills, dairy co-ops, banks, cooperatives	+ + + + + +
Pump repair, motor rewinding, tubewell deepening, etc. (Pump mechanics)	− − − − − −
Tubewell owners: quality and reliability of power supply	+ + +
Tubewell owners: No. of hours of power supply	− − −
Water buyers, landless laborers, tenants	− − − − − −
Groundwater irrigated area	− − −

Source: Shah & Verma (2008).

on the size of groundwater markets (i.e. whether they will expand, contract, or remain the same), and volume of groundwater extracted cannot be predicted *a priori* and has to be answered only empirically (Mukherji *et al*., 2009).

4.2 *Impact of JGS in Gujarat*

Jyotirgram has radically improved the quality of village life, spurred non-farm economic enterprises, halved power subsidy to agriculture and reduced groundwater draft. It has also offered a mixed bag to medium and large farmers but hit marginal farmers and the landless. These depend for their access to irrigation on water markets which have shrunk *post-Jyotirgram*; and water prices charged by tubewell owners have soared 30–50%. Table 1 summarizes the impact of the scheme on different groups of rural residents, including pump owners and water buyers.

Since over 90% of groundwater withdrawal in Gujarat occurs through electrified tubewells, electricity consumption is an accurate surrogate of aggregate groundwater withdrawal. Government figures suggest that farm power use on tubewells has fallen from 15,700 million kW·h/yr in 2001 to 9,900 million kW·h in 2006 – nearly a 37% decline. Unfortunately, pre-JGS figures on agricultural power use are residual figures, containing a portion of the T&D losses in other sectors, and therefore significantly inflate the extent of pre-JGS farm power use. However, even if we discount the 2001–02 figures, there is still a very substantial decline in agricultural power use; and halving of aggregate farm power subsidy, from US$ 788 million in 2001–02 to US$ 388 million in 2006–07. From this, we can infer that annual groundwater use in Gujarat agriculture has declined significantly during the same period. True, some of the decline may be caused by two successive good monsoons in 2005 and 2006; but there is unmistakable evidence of tubewell irrigation shrinking. Finally, it is evident that JGS has brought about unprecedented improvement in the quality of life of rural people, by creating a rural power supply environment qualitatively identical to urban one. The new era of round the clock high quality power supply in the countryside, without doubt, will unleash a myriad of impulses for socio-economic development and growth in the non-farm livelihoods in rural areas. Thus as a broad rural development intervention, JGS will prove instrumental in the future.

However, JGS's impact on the farming community has been generally negative and the intensity of this negative impact depends on the size of the land holding and the nature of the aquifer. In depleted alluvial aquifers of North Gujarat, where farmers can pump their deep tubewells continuously, feel adversely affected because the power ration restricts their irrigated area. But farmers in hard-rock areas are less affected because water available in their well during a day is a more binding constraint on their pumping than the hours of daily power supply. Small farmers owning tubewells are happy with improved power quality, although they miss their water selling business. Landless share croppers and water buyers are adversely affected everywhere because water markets have shrunk and water prices have soared 40–60%, driving many of them out of irrigated agriculture. The full import of rationed power supply has yet not been felt by the farmers because 2005 and 2006 were both good monsoon years when wells were full and water levels close to the ground. Come a drought year, and farmers will find the JGS ration of power too meager to meet their irrigation needs.

5 CONCLUSION AND POLICY IMPLICATIONS

India is in the midst of power sector reforms and states have chosen different pathways to reforms based on their political constituency. While most Indian states have resisted metering of agricultural tubewells, the state of West Bengal has embarked upon metering of all tubewells. In West Bengal, however, metering has benefitted a small section of wealthier pump owners at the cost of majority of small and marginal water buying farmers by changing the very incentive structure inherent in earlier flat tariff system, which encouraged pump owners to pro-actively sell water.

In view of this, our recommendations are the following:

a) In West Bengal, to safeguard the interest of the water buying farmers, the government should ease the process of electrification of tubewells and provide one time capital subsidy for constructing tubewells, especially for the small and marginal farmers. This will lead to increase in number of electric tubewells and enhanced competition in water markets through which water prices may come down in the future.
b) Village level governments (*panchayats*) can play an important role in West Bengal by regulating the price at which water is sold to the buyers.

The *Jyotirgram Scheme* in Gujarat has pioneered real-time co-management of electricity and groundwater irrigation. Its highly beneficial and liberating impacts on rural women, school children, village institutions and quality of rural life are all too evident; its impact on spurring the non-farm rural economy are incipient but all indicators suggest that this will be significant and deepen over time. But above all else, *Jyotirgram Scheme* has created a switch-on/off groundwater economy that is amenable to vigorous regulation at different levels. It can be used to reduce groundwater draft in resource-stressed areas and to stimulate it in water-abundant or water-logged areas; it can be used to stimulate conjunctive use of ground and surface water; it can be used to reward *feeder communities* that invest in groundwater recharge and penalize villages that overdraw groundwater.

Elsewhere in India and the rest of the world, groundwater managements have experimented with a diverse set of resource governance regimes – using water laws, tradable groundwater rights, economic incentives and disincentives – to achieve improved groundwater demand management for productivity, equity and sustainability. In their effectiveness, these regimes have proved ineffective, costly and time-consuming. In comparison, Gujarat under JGS has shown that effective rationing of power supply can indeed act as a powerful tool for groundwater demand management. And in so far as metering over 600,000 electric tubewells scattered over a large countryside may entail a very substantial transaction cost, which JGS saves, it may well be the *best* and not a second-best solution to the farm power imbroglio that all western and southern Indian states are confronted with.

As it is managed now, JGS has a big downside: its brunt is borne largely by marginal farmers, and landless because of the shrinking of water markets and of irrigated agriculture itself. There is no way of eliminating this completely, except by increasing hours of power supply – and subsidy, both of which will defeat the purpose of the entire initiative. However, JGS can significantly reduce the misery of the agrarian poor by replacing the present rationing schedule by an intelligent, demand-adjusted power rationing. The equity impact on the poor can be further enhanced by providing the daily power supply in two or more installments to respond to the behaviour of wells in hard rock areas. The equity impact can also be enhanced a great deal by charging a common flat tariff to all tubewells, regardless of whether metered or not. This would turn a large number of metered tariff paying tubewell owners from reticent sellers to aggressive water marketers to their poor neighbours.

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