

Brief History of Energy Management and the Case of the Small Island Developing State (SIDS) of Mauritius

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Abstract

Energy Management is defined as a systematic endeavor through engineering and management techniques to achieve optimum energy efficiency for specific political, economic and / environmental goals. The history of its evolution with specific reference to the case of a Small Island Developing State, that is, Mauritius, is discussed. Its importance and its obstacles are critically assessed as it happened over the past decades. In the Third Millennium, Energy Management should prove to be a vital tool for sustainable development. Mauritius is in a strategic position and satisfies the social as well as politico-economic conditions to emerge as a leading promoter of Energy Management in neighboring African and Asian countries. The future of Mauritius lies in its assuming responsible leadership in relation to Energy, Environment, Economy and Engineering issues affecting itself and its African and Asian neighbors.

Keywords: *Energy; Energy Efficiency; Energy Management; Mauritius; Sustainable Development.*

1. Introduction

The capacity to harness the use of energy is a characteristic of all human societies. According to Goudsblom [1], the ability to handle fire is a universal and an exclusively human attainment, ‘more remarkable than language or the use of tools. Yet, ‘Energy Management’ is a relatively new phraseology. Its definitions usually lie between two extremes: the business-oriented and the technology-oriented. To a large extent, the simplistic understanding of Energy Management as just another management concern reflects a business-oriented perception. On the other hand, considering Energy Management as a mere synonym for energy conservation often reflects a technology-oriented perception. The need to convince key decision-makers to promote Energy Management has indeed led to business-oriented definitions of Energy Management. Literature addressing decision-makers and managers promptly points out that Energy Management is a business issue [2]. Considering energy as a business asset has also brought a rapprochement between Energy Management and quality management. Total Quality Management (TQM) can act as a vehicle for the improvement of energy efficiency and can offer a good benchmarking structure for Energy Management [3].

However, the utilization of energy is also an engineering concern governed by the laws of Thermodynamics. Energy Management can therefore be defined to accommodate an engineering dimension. Energy Management is thus, according to O’Callaghan [4], a technical-cum-management function to monitor, record, analyze, critically examine, alter and control energy flows through systems so that energy is utilized with maximum efficiency.

Apart from nature of Energy Management, that is, whether business-oriented or technology oriented, the ultimate purpose of Energy Management deserves consideration. ‘Optimal use of

energy' [2], 'energy efficiency' [5] or 'maximum efficiency' [4] are various ways in which the primary objective of Energy Management has been described. Substitution of scarce and expensive energy by cheap and readily available resources has also been reckoned as a further objective [6].

Energy efficiency or the use of renewable for its own sake does not make much sense. The real reasons to justify Energy Management are not difficult to uncover. It was the oil crisis in 1973-1974 which drove engineers and managers to develop systematic approaches to the management of energy resources - ever since politico-economic interests have been the principal *raison-d'être* of Energy Management.

The linkage between Energy and Environment has always existed [7]. However, interest in the environmental damage due to energy use is now not only more pronounced but it also seems to have a global and a long-term reach. Energy Management can prove to be a solution to the environmental risks arising from human activities. Hence, thousands of companies have embarked on Energy Management programmes [8]. In addition to the potential environmental benefits, these companies and their countries of operation also reap economic and political gains.

Political, economic and environmental interests are omnipresent but are not the same at all times and in all places. Each country or organization has its own mix of the latter interests at a given point in its development. Most particularly, developing countries now need to have their own model of Energy Management. Such is the case for Mauritius. It is apt to define Energy Management as a systematic endeavor through engineering and management techniques to attain optimal energy use for specific political, economic and /or environmental reasons [9, 10]. As such, Energy Management is the tool par excellence for achieving a sustainable use of energy.

2. Importance of Energy Management

2.1. Political and Economic Importance

2.1.1. Energy Security

The political importance of Energy Management was basically derived from the dependence of most countries of the world on the import of energy, particularly, on the import of oil. About 55% of the proven oil reserves in the world are in Saudi Arabia, Kuwait, Iraq and Iran alone. At current consumption levels, the oil reserves in the world will not last more than 60 years. More than half of the reserves of natural gas in the world are in the former Soviet Union and in Iran alone. Among the areas of major energy exploration and production are Nigeria, Libya and Algeria. All these regions have been marked in the past by upheaval and unrest and are still reckoned as hot spots. The 1979 sharp rise in the price of oil following the Iran crisis brought the price of crude oil to above US\$ 60 / barrel (in terms of 1990 US\$). In late September 1990, oil prices reached a peak of US\$ 140 / barrel after the Iraqi invasion of Kuwait, an increase of more than 100 % compared to the price in June 1990 [11]. Countries around the world led by the United States would not have risked the life of hundreds of thousands of men and women at the time if they had no need of foreign oil. Energy security is too important a consideration for the world to remain passive in face of threats like the Iraqi invasion in 1990. This security was maintained at the cost of one of the biggest military operations since the Second World War and at the cost of the life of more than 100 000 people.

2.1.2. Increased Demand of Energy

In 1993, the world oil demand was increasing by only 0.1 million barrel / day. The latter figure representing an increase of less than 0.2 % was misleading because the fuel consumption in the

former Soviet Union alone decreased by 17 % compared to the consumption for 1992, a consequence of the collapse of the Soviet Union. Thus, outside the former Soviet Union, oil demand increased by 2 % with the strongest growth occurring in the Far East and in parts of Latin America [12]. This rise in demand is undesirable as long as the problem of energy security is not solved. Moreover, the fact that the growth in energy demand is higher in developing countries than in the industrialized world implies that energy security is becoming a more and more important concern for the former. All projections show increased use of energy in the developing world under the thrust of population growth and of industrialization. Even in the perspective of intensified energy-saving and energy efficiency to reduce the rate of demand growth in the South, the latter would still be needing as much energy as the North [13].

2.1.3. Reliance on the Importance of Fossil Fuel

The reliance on fossil fuel is a liability that can be countered by Energy Management. It should be a fundamental policy to reduce the reliance on fossil fuel in order to lessen the risks on the economy in the case of a sharp rise in prices and to face any possible disruption in the supply of fuel. Energy Management also offers direct economic advantages. If not by cutting down labor costs, reducing the cost of production is possible by Energy Management. Reduced consumption of fuel and reduced cost of production have an immediate impact on profitability. As far as the investment required is concerned, it is paid back within less than one year in a number of cases. Compared to efforts to increase profits by increasing sales, for example, Energy Management is less demanding. The former needs sustained management and marketing attention and are often accompanied by high-risk investments.

2.1.4. Increased Competitiveness

When it is important to be competitive on a long-term basis rather than to guarantee short-term profitability, cutting down production costs through Energy Management is a solution not to be neglected. In such cases, savings in terms of energy will not be used to increase the end-of-year profits but will help bring down the cost of the product with a view to increase the market share. Energy Management will also boost the competitiveness by enhancing quality and promoting quick response - these benefits naturally add to most improvements in energy efficiency.

2.1.5. Reduced Trade Deficit

In 1984, the import of fuel in Mauritius reached 18 % of the total value of our imports. The Government launched a series of investigations into energy use with emphasis on the domestic and industrial sectors. However, as the share of the energy item in the import bill decreased in the subsequent years, less and less attention was addressed to the issue. It is true that in 1999, for example, the import of fuel represented only about 7 % of total imports. However, in 1999, Mauritius was using at least four times more imported energy than in 1984. The level of total import has increased at a faster rate such that a fall in the ratio of fuel import to total import is to be expected [14]. Thus, Energy Management is at least as important now as it was in 1984 when the Government thought it worthwhile to emphasize on energy conservation in its Development Plan [15]. Even if today oil import does not weigh very heavily in the trade deficit, at least for now, it is to be feared that an increase in world oil prices will be a severe blow to the economy. In 1999, the trade deficit reached Rs 16.6 billion compared to only Rs 4.5 billion in 1992 [14]. As a means to reduce the trade deficit, a control on the import of foodstuff and of manufactured goods is both unpopular and contrary to the spirit of economic liberalization (the latter items contribute

to more than 50 % of imports). Similarly, imports for the Export Processing Zone (EPZ) in terms of raw materials and machinery (about 30 % of imports) cannot be easily reduced without affecting the performance of the EPZ. If it is imperative to curb down the trade deficit, then Energy Management is a practical solution, which should not be neglected. In addition, energy imports are traded in US dollar, which is appreciating steadily, compared to the Mauritian rupee.

2.1.6. Energy Services: A Regional Industry

An energy services industry answers the concern of the Government to diversify the economy in new directions. Supplying energy and related services makes up an industry that the authorities are keen to develop. Four multi-national oil companies are active in Mauritius in the distribution of fuel. Bunkering fuel for planes and ships and re-exporting gas to the region have added a regional dimension to the industry. Energy efficiency also has a promising market, particularly, in view of the fact that similar prospects of Energy Management as in the textile industry exist in other sectors such as the sugar industry and the food-processing industry, locally and in the region. Export possibilities exist towards the South and East African region particularly towards the Common Market of South and East Africa (COMESA). The admission of Mauritius to the Southern African Development Community (SADC) and the Indian Ocean Rim (IOR) initiative for regional cooperation offer new trade possibilities. The Freeport and the Offshore-banking sector of Mauritius should facilitate the growth of the energy services industry. Imported energy efficient technology can be assembled and processed in Mauritius to be re-exported to neighboring countries. Penetration into the regional market is easier for far-away manufacturers in Europe, America and the Far East if they adopt Mauritius as a launching pad. A share of the latter market of only 0.1 % will be enough to give rise to a full-fledged energy efficiency products and services industry in the region. Mauritius satisfies the geographical, political and economic requirements to become the focal point of that industry.

2.2. Environmental Importance

2.2.1. Less Energy Implies Less Pollution

A simple relationship that is often forgotten is that less energy implies less pollution. Regulations in some countries reckon the importance of the latter relationship and set different norms for different levels of energy use. Industrial plants can often avoid the more strict rules applicable to high-consumption plants by promoting Energy Management in order to be included in the low-consumption level where the regulations are easily satisfied.

Less energy also implies less material. An example is the use of steam in the textile industry. A reduction in steam demand leads not only to a reduction in the fuel input and in associated emissions but also to a lower requirement of water - an extremely valuable resource. Other advantages of a more efficient use of steam occur as lower pumping costs, fewer chemicals used in water treatment, and less water pollution since steam often finishes as high temperature wastewater at the end of the cycle of textile processing. In the case of solid fuels, the problems of ash disposal, smoke and grit are minimized by Energy Management.

2.2.2. Coupling of Energy Management and Environmental Protection

Industry may be required by the authorities to install pollution control equipment. The installation of the latter invariably brings no direct return on investment. On the other hand, the introduction of pollution control technology increases operation and maintenance costs. However, coupling an appropriate high pay-back Energy Management investment with the stipulated pollution control

investment generates funds to help pay for the latter. One example is the conversion from fuel oil to LPG (liquefied petroleum gas). This conversion permits the use of an economizer to recover energy from the flue gas to preheat boiler water. The reduction in fuel consumption due to the economizer at least partially pays for the fuel conversion and for the investment in the economizer. Another example is the heat recovery of hot wastewater in a heat exchanger to warm process water. The temperature of the wastewater is thus suitably lowered to make bacteriological treatment possible. The cost of the treatment plant is partially offset by the saving from the heat recovery system.

2.2.3. Environmental Competitiveness

The advent of Eco-label for textile products, the spread of the ISO 14 000 standards, the attempt to include environmental issues on the agenda of the World Trade Organization (WTO), the growing number of conventions on energy and environment are issues to which Mauritius as well as most developing countries, including Small Island Developing States, cannot remain insensitive. It is sufficient that a few pictures of pollution in Mauritius are circulated in the media in Europe or in the U.S for the Made in Mauritius label to take a severe blow in the competitive textile market. Companies are increasingly concerned about their public image especially at a time when customers and investors are sympathetic to environmental issues. Thus, Energy Management is important, as it is part of the wider domain of Environmental Management.

2.2.4. Conquering the Climate Change Challenge

The evolution of the European and U.S legislation on pollution shows that the concern of environmental degradation has changed over the last centuries. The creation of the Environmental Protection Agency (EPA) in the U.S in 1970 was a turning point; it happened at a time when the environmental movement was emerging as a power to reckon with and when a transition in the concept of pollution was occurring. Before, pollution was short-living, localized and limited mostly to large cities. After the 1970s, pollution became associated with irreversible, long-term and possibly catastrophic consequences on a planetary scale. Industrialized countries are adopting targets to curb carbon dioxide emissions in view of countering the threat of global climate change.

Even if there is no absolute certainty that carbon dioxide emissions - originating mostly from fossil fuel combustion - leads to a global climate change, the risk is sufficient justification for adopting preventive measures. So even climate skeptics should have reason to adopt Energy Management. However, it is relevant to question the extent to which resources should be devoted to such a preventive strategy in view of the growing scarcity of means and of the need for development, particularly in the developing world. A minimum regret approach is to be favored by developing nations like Mauritius: actions taken to curb carbon dioxide emissions should yield primary benefits such as cost savings. In the very unlikely event that the world got it all wrong concerning the threat of global climate change due to carbon dioxide emissions, there should be minimum regret for the actions taken.

Energy Management actions are minimum regret actions. The importance of Energy Management irrespective of the climate change implication has already been discussed. Energy efficiency and conservation measures - optimized through Energy Management - have long been recognized as beneficial. The Green Energy Conference held in Montreal in September 1989 concluded in colorful terms that 'Energy conservation is the most abundant, least expensive, safest, cleanest and most reliable form of energy in the world today' [16]. The United States Energy Association

(USEA) has proposed a five-point plan to adopt energy efficiency measures calling for ‘the United States and other nations in a spirit of common interest and common sense to get down to business in fully realising the potential of energy efficiency’ [17]. The various scenarios that have been proposed for sustainable energy uses all underline the importance of energy efficiency [18,19]. The World Energy Council acknowledges that there is a general agreement to give priority to energy efficiency even in countries of the South with low consumption levels [20] like Mauritius. In its programme as far back as the nineties, the Government of Mauritius included the objective of promoting energy conservation measures at consumer level as well as at production and distribution levels. Several publications have underlined such a commitment of the Government [21]. The National Long-Term Perspective Study specifically refers to the objective of ‘sensible conservation’ as a means of achieving self-sufficiency in energy [22].

2.3. Obstacles to Energy Management

2.3.1. Political Obstacles

Energy policy is a sensitive issue, often with important political ramifications. The failure of the British Government of John Major to obtain the approval of the House of Commons in 1994 on a proposed increase in the price of domestic fuel is a famous case in point. Although the direct objective of the British Government was to cut down the budget deficit, such a move would have also encouraged energy saving, hence, reduce the import of oil in the interest of the country. What the vote in the House of Commons demonstrates is that any unpopular decision is unlikely to succeed in a democratic society.

2.3.2. Economic Obstacles

Dependence on the simplistic concept of economic rationality with energy sources considered at their historical prices leads to a dwindling incentive for Energy Management at a time when these prices are decreasing. In real terms, except for the recent tendencies noted, the price of energy has been on a decreasing trend since the peak reached in the early eighties. The cost of other factors of production has, however, increased such that lower importance is being attached by industry and by the authorities to the energy budget.

2.3.3. Lack of Information and Energy Illiteracy

In spite of their apparent feasibility, a lack of interest has been observed in several Energy Management projects. Such a situation is often due to a lack of reliable information on the breakdown of the energy demand, on the availability, on the costs and on the potential of the energy efficiency technologies. Such a problem is acute in developing countries, including Mauritius, in spite of the particular efforts of the University of Mauritius and of the Central Statistics Office (CSO).

Another cause of the low interest in Energy Management is energy illiteracy. Energy education is the concern of all although the type and level of education should be a function of occupation. Energy teaching should be enforced not only at school and college levels but it should also be an integral part of any University education as it is a concern of engineers, managers, economists, politicians, business people, social scientists, environmentalists and journalists alike. Unfortunately, even in developed countries, energy teaching is often overlooked in many University curriculums [20, 23].

2.3.4. Uncertainty and Confusion

Different countries have reacted very differently to the threat of environmental problems, particularly, to the risk of a global climate change. Strategies adopted range from the implementation of energy taxes (like in Denmark, Netherlands, Finland, Norway and Swede) to non-binding commitments to targets (like in many developed countries) [24]. Most developing countries, including Mauritius, have yet to react to environmental problems through much concrete policies and strategies. The response of the latter - India and China, most particularly - over the next few years and into the Third Millennium is critical as the major portion of the world energy demand shifts to these countries. Such a response is however unpredictable yet. There has also long been serious doubt on whether developed countries, most particularly the United States, will react as initially expected from them to curb down on carbon dioxide emissions [25]. Although not as vehement as it used to be, criticism continues to be made, among others, on the uncertainty of environmental catastrophes happening, on the effectiveness of carbon taxation, on what should be the best mix of energy sources for the future and on what can developing nations afford to do. The volatile nature of energy prices (matched only by the state of conflicts in the Middle-East) and the delay as well as the doubts over getting a breakthrough in the search for a feasible large-scale substitute for fossil fuel add to the atmosphere of uncertainty and confusion. In developing countries like Mauritius, on occasion, interest is shown in ambitious renewable energy projects only to abandon the idea after the initial enthusiasm has passed - and it is found that the feasibility is doubtful. Ultimately, energy production is favored at the expense of the use of renewable energy and demand-side management. As a result, the progress of Energy Management is suffering.

2.4. Brief History: Energy Management in Mauritius

Literature on the evaluation of early Energy Management programs is generally scarce [26]. This is particularly true for Energy Management in Mauritius although the specific topic of Energy Use and Policy Planning in Mauritius has been addressed a number of times in the past [27]. In what follows, Energy Management in Mauritius is summarized with special focus on points of relevance to the current research work.

2.4.1. Overview

Substituting one form of energy for another is part of the history of Mauritius: boats and animal-driven carts gave way to trains and, later, to motor vehicles; oxen were replaced by steam-power in sugar mills; kerosene and, later, LPG came into use instead of wood fuel and charcoal for cooking. Today, the combustion of bagasse as opposed to oil for electricity generation is promoted and there is a trend towards favoring LPG, particularly in industry and in the domestic sector. Apart from substitution, Energy Management has also taken the form of a persistent introduction of more energy efficient technology over the years - associated with a desire to improve productivity or the standard of living. Conservation programmes never attained the peak observed in other countries because Mauritius was, to some extent, spared from the oil crisis of 1973-74 that coincided with the sharp increase in world sugar prices - the main export of the island - and the development of hydropower and bagasse-fuelled electricity generation [28].

2.4.2. Organization

There was no central body responsible specifically for Energy Management in Mauritius like the Agence de Environnement et la Maîtrise de l'Énergie (ADEME) in France or the Energy Efficiency Office (EEO) in the UK until the Energy Efficiency Management Office (EEMO) was

set up in 2011. Under the aegis of the ex-Ministry of Energy, an Energy Planning and Development Division (EPDD) was set up in the eighties in order to investigate the use of energy in industry and in the domestic sector. The assistance of the British Overseas Development Agency (ODA) was precious in initiating several of the activities of the EPDD, namely, the conduct of energy audits and of energy data analysis. However, as the share of the energy budget for the country decreased in the subsequent years, the enthusiasm, which marked the early activities of the EPDD gradually, disappeared. In 1996, the Ministry of Energy was re-styled as the Ministry of Local Government and Utilities and in 1997, it became the Ministry of Public Utilities.

2.4.3. Energy Pricing

The Government has always set the price of energy. To boost the expansion of the Export Processing Zone (EPZ), the authorities have been offering incentives to investors and, in some circle, it is considered out of question to increase the price of energy by moderate market intervention. The use of energy for industrial purposes is not directly subsidized but no duties or taxes are imposed on energy purchased by the EPZ. Preferential tariffs occur for electricity for the latter. The State Trading Corporation (STC) is the government-owned body responsible for importing fuel.

2.4.4. Absence of Specific Regulations

There are no specific regulations on energy efficiency except for labels. Some standards on air quality, emissions and wastewater disposal have now been introduced under the Environmental Protection Act, but the monitoring of the compliance is difficult due to a lack of trained personnel and of proper equipment. However, the authorities can order any polluter to cease its activity if necessary. Before the setting up of a Department of Environment in the nineties, it was difficult to co-ordinate pollution control actions. The Department of Environment is a relatively new organism and its successful implementation and interaction can only be a gradual process. In any case, its priority is not Energy Management although the environmental impact of energy use is one of its concerns.

2.4.5. Energy Services Sector

Energy Management loses its competitiveness whenever there is a relatively low price of energy in the world market and a relatively high cost of services related to energy saving. Few in the energy services sector accept the risks of carrying stocks of materials or equipment - an observation also made in 1985 in the context of an EPDD project [29]. Loan facilities are available from the Development Bank of Mauritius but since these facilities have not been designed specifically for Energy Management, it has not been possible to encourage industries to invest in Energy Management. Similarly, incentives like taxation abatement and subsidies through the Technology Diffusion Scheme have not served the cause of Energy Management. In 1996-97, two major companies in the energy services sector closed down. More recently under the funding provided by the French Development Agency, banks have proposed sustainable energy support programmes.

2.4.6. Energy Education

The lack of qualified and trained staff was one of the difficulties faced by the EPDD. In industry, few people are aware of the various requirements of Energy Management. When the ODA expert collaborating with the EPDD called for the appointment of Energy Managers in industry, there

was no positive response. The definition of the job of an Energy Manager and the differentiation of the latter's role from that of the Maintenance Manager in the specific context of the textile industry in Mauritius is a problem that has yet to be resolved. The absence of proper Energy Education and the related Environmental Engineering training in some universities is a problem. There is also not enough in terms of Energy Education at primary and secondary school levels or at vocational training level.

2.4.7. Education and Training

However, this does not mean that there is no demand for Energy Education. A crash course in 1994 on Steam Engineering for technicians in industry proved to be a real success. More than forty managers and engineers participated in the seminars on Energy Management held at the University of Mauritius in 1995 and in 1997. The links between the industrial sector and research groups at the University have led to several joint-projects. With particular reference to the textile industry, about half a dozen projects have been undertaken on Energy and the Textile Industry by final-year Engineering students at the University [30-32]. However, each study was limited to one specific plant and the objective, methodology and conclusions of these projects have been found to be largely overlapping. Such investigations have rarely led to implementations. The poor definition of Energy Management solutions and, more seriously, the absence of cost-benefit appraisals were the major shortcomings of some projects. It was also seldom understood that conservation would be more meaningful in the wider context of Energy Management. As most of the research was conducted in the eighties, there was no reference to long-term environmental problems. Local pollution, which was an emerging problem at that time, was not sufficiently covered. However, these projects have the merit of being among the pioneering research works in Mauritius in the field of energy use in the textile industry. All of them had in essence one very important claim: there is a large potential for Energy Management in the textile industry in Mauritius. Auditors have now also been trained through the EEMO.

3. Conclusions

The setting up of the Energy Efficiency Management Office (EEMO) in 2011 has been a milestone in the endeavor to achieve a sustainable use of energy in Mauritius. Its role should evolve gradually in the light of the Government policies to include the following:

- Facilitate implementation of Energy Management in the domestic sector, in buildings and in the commercial sector, in manufacturing industries, in the transport sector, in the sugar industry as well as in hotels and restaurants.
- Facilitate the optimization of the use of energy in all its forms with particular attention to the use of steam (in manufacturing and sugar industries mainly) and of electricity (in the domestic sector mainly).
- Conduct energy audits and energy awareness campaigns in different sectors jointly with the Ministry of Environment, industry and non-governmental organizations.
- Further research is required in order to assess the likely behavioral effects of a broad-based energy tax or an environmental tax on the economy and on the Environment. Analyzing the impacts of the proposed energy tax applicable only to dyeing and finishing plants in Mauritius can provide deep insight into the latter issue.

Investigating the relationship between Energy Management and Waste Minimization can help optimise the usage of both water and energy by identifying the critical measures to be taken in

dyeing and finishing plants. Water Management is a field of further research in its own right.

Last but not least, proposed Energy Management programs should be examined and updated at least every three years. Similar programmes with appropriate modifications can be produced for industries or other sectors, both in Mauritius and in the region. Just as Energy Management can serve as a vector for the modernization of industry in Mauritius, it can be the means to attain other objectives in different situations. Three such examples are given below:

- Energy Management is a means to increase the electricity output derived from the combustion of bagasse in the sugar industry in Mauritius.
- Energy Management is a means to reduce pollution due to solid waste disposal in fast-growing cities of the Third World.
- Energy Management is a means to fight poverty and improve living standards in remote islands or villages in Africa or in the Indian Ocean region where electricity supply is not available or where energy resources are scarce.

In all cases, Energy Management is a formidable tool for a sustainable use of energy.

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