Sustainable Energy Resources in India-Future Approach

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Abstract*— The Renewable energy sources and technologies have potential to provide solutions to the long-standing energy problems being faced by the developing countries. Renewable energy sources like wind energy, solar energy, hydel energy, geothermal energy, tidal, biomass energy and fuel cell technology can be used to overcome energy shortage in India. Since the energy requirement would increase to 3 to 4 times the current requirement in future and the requirement can be fulfilled by renewable energy resources. India is increasingly adopting responsible renewable energy techniques and taking positive steps towards carbon emissions, cleaning the air and ensuring a more sustainable future. India has tremendous energy needs and it is becoming increasingly difficult to meet those needs through traditional means of power generation. Over 40% of rural Indian households don't have electricity. While India is developing domestic energy sources to satisfy the growing demand, it is also anxious about having to import increasing amounts of fossil fuels that exacerbate the trade deficit and can be harmful to the environment. The present centralized model of power generation, transmission and distribution is growing more and more costly to maintain and, at the same time restricts the flexibility required to meet growing energy demands. India needs to encourage a decentralized business model in order to more readily take the advantage of abundantly available renewable energy sources. To that renewable resources are the most attractive investment because they will also provide long term economic growth for India. Small hydro has been growing in India at a slow but steady pace. In this paper, efforts have been made to summarize the availability, current status, major achievements and future potentials of renewable energy options in India.

Keywords*— *Renewable energy, Current scenario, Future Trends.

I. INTRODUCTION

The World Energy Forum has predicted that fossil-based oil, coal and gas reserves will be exhausted in less than another ten decades. Fossil fuels account for over 79 % of the primary energy consumed in the world, and 57.75 of that amount is used in the transport sector and are diminishing rapidly. Exhaustion of natural resources and the accelerated demand of conventional energy have forced planners and policy makers to look for alternate sources. Renewable energy is energy derived from resources that are regenerative, and do not deplete over time. Renewable energy offers our planet a chance to reduce carbon emissions, clean the air, and put our civilization on a more sustainable footing. It also offers countries around the world the chance to improve their energy security and spur economic development. The coal share has continued to grow reaching about 30% of total consumption, Most of that growth came from China, but interestingly, while coal consumption dropped sharply in the U.S in 2012, it rose in Europe for the third straight year, as natural gas prices rose sharply there. Renewable sources are growing rapidly, but were just 1.9% of total consumption in 2012. Still that is up quite a bit in percentage terms from its 1.6% World energy consumption. The usage of renewable energy resources is promising prospect for the future as an alternative to conventional energy, the availability of renewable energy options in India provides information about the current status of renewable future potentials of their uses major achievements and current government politics delivery and outreach in Indian context. It paints a remarkable overall picture of renewable energy resources and position of India on global map in utilizing these resources.

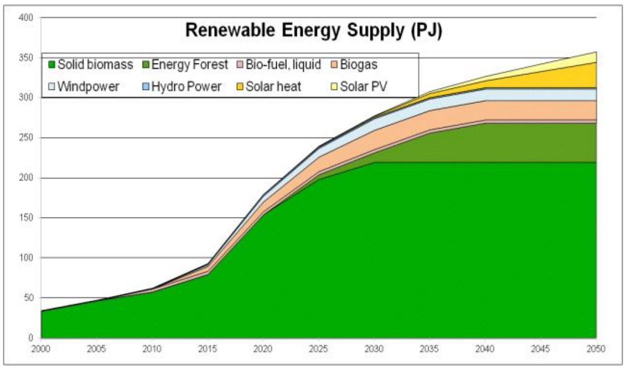


Fig.1. Renewable Energy sources

II. ENERGY SOURCES

2.1 Generation of Energy

Energy is a basic requirement for economic development and in every sector of Indian economy. It is thus necessary that India quickly look towards new and emerging renewable energy and energy efficient technologies as well as implement energy conservation laws. Against this background, the country urgently needs to develop a sustainable path of energy development. Promotion of energy conservation and increased use of renewable energy sources are the twin planks of a sustainable energy supply. Fortunately, India is blessed with a variety of renewable energy sources, like biomass, the solar, wind, geothermal and small hydropower and implementing one of the world's largest programs in renewable energy. India is determined to becoming one of the world's leading clean energy producers. The government of India has already made several provisions and established many agencies that will help it to achieve its goal. The country has an estimated renewable energy potential of around 200,000 MW from commercially exploitable sources, Example wind, 49,000 MW, small hydro 20,000 MW and biomass/bio energy, 26000 MW. In addition India has the potential to generate 35 MW per square kilometer using solar photovoltaic and solar thermal energy. There has been phenomenal progress in wind power and with an installed capacity of over 18192 MW India occupies the fifth position globally.

2.2 Statistics of Energy consumption

The role of new and renewable energy has been assuming increasing significance in recent times with the growing concern for the country's energy security. The renewable energy industry has approximately USD 500 million as turnover, the investment being about USD 3 billion. The estimated potential of 200,000 MW from RE only about 25000 MW has been installed to date. The Indian government has been at work, making a comprehensive policy for compulsory use of renewable energy resources through biomass, hydropower, wind, solar and municipal waste in the country particularly for commercial well as government establishments

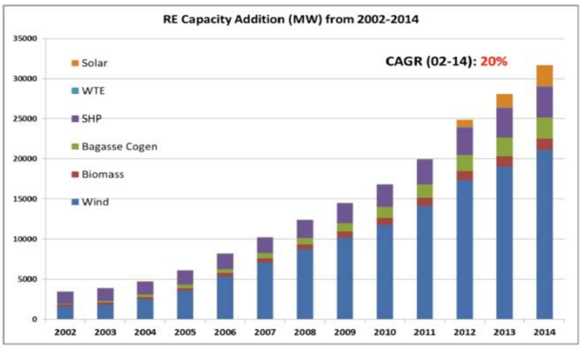
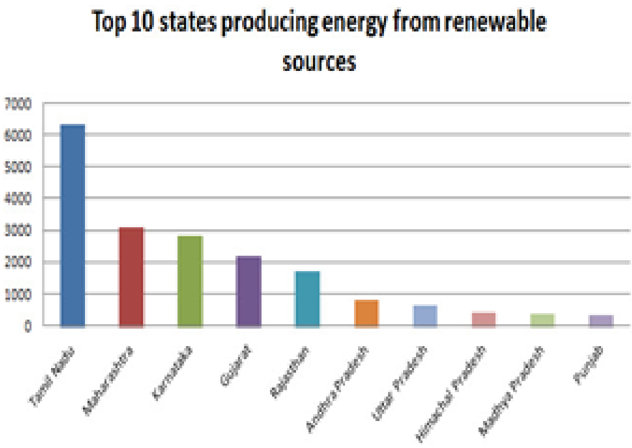


Fig.2. Energy consumption statistics

2.3 Statewise energy consumption

Renewable energy is the only technology that offers India the theoretical potential to service all its long term power requirements.. For instance taking advantage of 300 to 330 sunny days a year, India could easily generate 500 trillion kWh of solar energy, which is higher than India's total yearly energy consumption. Even if a tenth of this potential was utilized, it could mark the end of India's power problems. Using the country's deserts and farm land, India could easily install around 1,000 GW of solar generation equivalent to around four times the current peak power demand (India's present generation capacity is about 210 GW)



Wind energy can also help India convert to 100 % renewable energy. According to the environmental group World Wide Fund for Nature (WWF), while India has no estimates of its offshore wind potential, up to 170 GW could be installed by 2050 along the 7,500 Km of coastline. Hydropower could generate an estimated 148 GW, Geothermal around 10.7 GW and Tidal power about 15 GW. If these abundantly available resources were properly developed and utilized, all of india's new energy production could be derived from renewable energy sources by 2030. In addition, all existing generation could be converted to renewable energy by 2050 while maintaining a reliable power supply in the interim. Barriers to implementing the renewable energy plan are seen to be primarily economic

III. AVAILABLE ENERGY

3.1 Biomass energy

Biomass includes solid biomass (organic, non-fossil material of biological origins), biogas (principally methane and carbon dioxide produced by anaerobic digestion of biomass and combusted to produce heat and/or power), liquid biofuels (bio-based liquid fuel from biomass transformation, mainly used in transportation applications) and municipal waste (wastes produced by the residential, commercial and public services sectors and incinerated in specific installations to produce heat and/or power). The most successful forms of biomass are sugar cane bagasse in agriculture, pulp and paper residues in forestry and manure in livestock residues. It is argued that biomass can directly substitute fossil fuels as more effective in decreasing atmospheric CO_2 than carbon sequestration in trees. Biomass may be used in a number of ways to produce energy. Most common methods are 1. Combustion 2. Gasification 3. Fermentation 4. Anaerobic digestion. India is very rich in biomass. It has a potential of 22,000 MW. Currently, India has 3,360 MW commissioned. The facts reinforce the idea of a commitment by India to develop these resources of power production.

Fig.3. Biomass energy

In India, more than 2000 gasifiers have been established with a capacity in excess of 22 MW and a number of villages have been electrified with biomass gasifier based generators. Being an agrarian country there is easy availability of agricultural based mass, which can be used to generate energy, burning this biomass is the easiest and oldest method of generating energy and also the least efficient. Over 70 % of the population of India is in villages but it is these villages, which receive neither electricity nor a steady supply of water-crucial to survival and economic and social development and growth. Biomass exists in these villages and needs to be tapped intelligently to provide not only electricity but also water to irrigate and cultivate fields to further increase production of biomass (either as a main product or as a by-product), ensuring steady generation of electricity. Biomass gasification in India offers immense scope and potential for water pumping, electricity generation 3 to 1 MW power plants, Heat generation: for cooking gas – smokeless environment. Rural electrification means better healthcare, better education and improved quality of life.

Despite advancements in biomass energy technologies most bioenergy consumption in India still remains confined to traditional uses. The modern technologies offer possibilities to convert biomass into synthetic gaseous or liquid fuels (like ethanol or methanol) and electricity. Modern biomass has potential to penetrate in four segments-i) process heat applications in industries generating biomass waste, ii) cooking energy in domestic and commercial sectors (through charcoal and briquettes), iii) electricity generation iv) transportation sector with liquid fuels. Economic reforms have opened the doors for competition in energy and electricity sectors in India. Future of biomass energy depends on providing reliable energy services at competitive cost. In India, this will happen only if biomass energy services can compete on a fair market. Policy priorities should be to orient biomass energy services towards market and to reform the market towards fair compensation by internalizing the externalities of competing energy resources. Most economical option is utilization of waste materials. Potential availability of agro residues and wood processing waste in India can sustain 10,000 MW power. Biomass waste however shall be in adequate to support the growing demands for biomass resources. Sustained supply of biomass shall require production of energy crops (e.g. Wood fuel plantations, sugar cane as feedstock for ethanol) and wood plantations for meeting growing non –energy needs. The benefits of biomass are listed as follows:

1. Biomass energy is not associated with environmental impacts such as acid rain, mine spoils, open pits, oil spills, radioactive waste disposal or the damming of rivers
2. Biomass fuels are sustainable. The green plants from which biomass fuels are derived fix carbon dioxide as they grow, so their use does not add to the levels of atmospheric carbon. In addition, using refuse as a fuel avoids polluting landfill disposal
3. Alcohols and other fuels produced by biomass are efficient, viable, and relatively clean burning.

3.2 Solar Energy

Solar power has so far played an almost non-existent role in the Indian energy mix. The grid-connected capacity in the country now stands at 1045 MW, while the total solar energy potential has been estimated at 100,000 MW. Most parts of India have 300-330 sunny days in a year, which is equivalent to over 5000 trillion KWh per year. Average solar incidence stands at a robust 4-7 KWh/sqmm/day. About 66 MW of aggregate capacity is installed for various applications comprising one million industrial PV systems- 80%of which is solar lanterns, home/street lighting and solar water pumps, among others India has high solar insolation, providing an ideal combination for solar power in India. Much of the country does not have an electrical grid, so one of the first applications of solar power has been for water pumping to begin replacing India's four to five million diesel powered water pumps, each consuming about 3.5 kilowatts and off-grid lighting.

Fig.4. Solar Panels

Some large projects have been proposed, and a 35,000 km^2 area of Thar Desert has been set aside for solar power projects, sufficient to generate 700 to 2,100 GW.Electricity is produced when radiant energy from the sun strikes the solar cell, causing the electrons to move around. The action of the electrons starts an electric current.

Fig.5. solar panel in Aircraft

The conversion of sunlight into electricity takes place silently and instantly. There are no mechanical parts to wear out. Compared to other ways of making electricity, photovoltaic systems are expensive and many panels are needed to equal the electricity generated at other types of plants. It can cost 10 to 30 cents per kilowatt-hour to produce electricity from solar cells. Most people pay their electric companies about 12.5 cents per kilowatt-hour for the electricity they use, and large industrial consumers pay less. Solar systems often used to generate electricity in remote areas that are a long way from electric power lines. In 2015, the desert sunlight solar project in opened at California. It is the largest photovoltaic plant in the world, generating 550 MW of electricity- enough to power over 150,000 homes.

In the latest 2016 budget the government has finished the amount of 500 crores to develop some mega projects in Gujarat, Tamilnadu, and Rajasthan. The solar power driven agricultural water pumping station and 1 MW solar parks on canal banks will be developed in the country. Considering all these matter we have bright future in the front of us India potential to be a solar power driven country in the world. Jawaharlal Nehru solar mission has aimed to produce 20,000 MW by 2022. In 2009, MNRE launched Jawaharlal Nehru National Solar Mission (JNNSM) with the ambitious goal of making India a global leader in solar energy. JNNSM plans a three phase approach with specific targets for each phase as given in (Table1). The Government of India has pledged to foster less carbon-intensive economic production in the country. It has planned to boost energy capacity to 175 GW by 2022 and target of clean energy generation through solar alone has steeply increased to 100 GW, The overall aim to source at 40% from clean source such as solar, wind by 2030.

TABLE 1 SOLAR POWER CONSUMPTION

Solar Applications	**Target Phase-1**	**Target Phase-2**	**Target phase-3**
Solar thermal collectors	7Mn.Sq.m	15Mn.Sq.m	20Mn.Sq.m
Off grid solar applications	200MW	1000MW	2000MW
Utility grid applications	1000-2000 MW	400-10,000 MW	20,000MW

3.4 Wind Energy

The development of wind power in India began in the 1990's and has significantly increased in the last few years. Although a relative newcomer to the wind industry compared with Denmark or the U.S, India has the fifth largest installed wind power capacity in the world. The world wide installed capacity of wind power reached 157,899 MW by the end of 2009 USA (35,159 MW), Germany (25,777 MW), Spain (19,149 MW) and China (25,104 MW) are ahead of India in fifth position (Table 3). The short gestation period for installing wind turbines and the increasing reliability and performance of wind energy machines has made wind power a favoured choice for capacity addition in India. Samana wind farm is the largest wind project undertaken to date by RULON. CLP India, the group's subsidiary in India is partnering with wind turbine manufacturer Enercon (India) limited to develop this Greenfield project in India's north-western state of Gujarat.

Fig.6. Wind power generation in Tirupur(Tamilnadu)

Samana wind farm has a generating capacity of 100.8 MW and is expected to be completed in two phases-the first 50.4 MW by January 2009. The project further leads RULON into the wind power market of India Suzlon India's largest wind power company has risen to ranking 5th World wide with 7.7 % of the global market share in just over a de. Suzlon holds some 52 % of market share in India. Suzlon's success has made India the developing country leader in advanced wind turbine technology. Tamil Nadu is the leading producer of wind energy with a total installed capacity of 7,276 MW, accounting 34% of India's total wind capacity. Except 2007, Tamil Nadu's annual capacity addition has been highest among all the states since 2002. In 2011, Tamil Nadu has achieved another success by installing 1,083 MW wind energy in a single year, which is highest annual installation by any Indian state in single year. In the recent past, districts of Coimbatore, Tiruppur and Theni are the locations where the maximum numbers of wind turbines are getting installed. The spectacular maximum number of wind turbines is getting installed. The spectacular growth of wind energy in Tamilnadu is attributed to c0nsistent effort of government to assess wind resource potential and setup conductive policies to attract private investment.

The Indian wind energy industry experiences two seasonal winds – the southwest monsoon (June to September) and northeast monsoon (October to December). The northeast monsoon, commonly known as winter monsoon mostly benefits Tamilnadu, whereas southwest monsoon, known as summer monsoon blows from sea to land ensuring sufficient wind speeds in the southern and western regions of the country. The southwest monsoon is predominant and majority of the wind power generation in the range of 65-90 per cent of the annual yield takes place during these months. From January to May wind availability drops resulting in less power generation. The foundation stone to harness renewable energy sources was first laid in India in the year 1982 with the establishment of the Department of Non-conventional Energy Sources (DNES), in the ministry of Energy. The Department had the responsibility of formulating policies and programmes of development of new and renewable energy apart from coordinating and intensifying R&D in the sector.

3.5 Tidal Energy

Generation of electrical power from ocean tides is very similar to traditional hydroelectric power generation. The simplest generation system for tidal plants involves a dam, known as barrage, across an inlet. Usually, a tidal power plant consists of a tidal pond created by a dam, a powerhouse containing a turbo-generator, and a sluice gate to allow the bidirectional tidal flow. The rising tidal waters fill the tidal basin after opening the gate of the dam, during the flood tide. The gates are closed, when the dam filled to capacity. After the ocean water has receded, the tidal basin is released through a turbo-generator. India as a result of being surrounded by sea on three sides, has a high potential to harness tidal energy.

Fig.7.. Tidal Generation in Gulf of Kutch(Gujarat)

The Ganges Delta also has good locations for small scale tidal power development. The maximum tidal range in Sundarbans is approximately 5 m with an average tidal range of 2.97 m. The identified economic tidal power potential in India is to the order of 8,000-9,000 *MW* with about 7,000 MW in the Gulf of Cambay, about 1,200 MW in the Gulf of Kutch and less than 100 MW in Sundarbans. The Kutch Tidal Power Project – with an installed capacity of about 900 MW –is estimated to cost about INR 1,460 crore generating electricity at about 90 paise per unit. The techno-economic feasibility report is now being examined. The West Bengal Renewable Energy Development Authority (WBREDA) has authorized NHPC Ltd. To prepare a deatailed project report on Durghadhauni Mini Tidal Energy plant with a capacity of 3.65 MW installed in the Sunderbans. The plant, which was developed by a joint collaboration between Indian Institute of Technology (IIT), Madras and National Institute of Ocean Technology (NIOT), Tamil Nadu – is providing electricity to nearly 15,000 homes.

Tidal turbines and wind turbines are similar in both appearance and structure to some extent. Tidal turbines can be located river estuaries and wherever there is a strong tidal flow. Since water is about 800 times as dense as air, tidal turbines have to be much stronger than wind turbines. They will be heavier and more costly they will be able to capture more energy at much higher densities usually tidal fences are mounted in the entrance of ocean channels

TABLE 2 TIDAL POWER CAPACITY

Plant owner	Plant developer	Plant type	Plant location	Installed capacity in (MW)
West Bengal Renewable Energy Develop-ment Agency	National hydro power corporation	Tidal Power Project	(West bengal) Delta of Ganga, Sundarbans	3.75
Gujarat Renewable Energy Development Agency		Tidal Power Project	(Gujarat) Gulf of Kutch	900
National Institute of Ocean Technology	National Institute of Ocean Technology	Wave energy project	(Kerala) Vizhinjam Fisheries Harbor	0.15

3.6 Geo-Thermal Energy

Geothermal energy is the earths natural heat available inside the earth. This thermal energy contained in the rock and fluid that filled up fractures and pores in earths crust can profitably be used for various purposes. This energy is accessed by drilling water or steam wells in a process similar to drilling for oil. Geothermal energy is an enormous, underused heat and power resource that is clean (emits little or no green house gases), reliable (average system availability of 95 %), and home grown (making us less dependent on foreign oil). India has reasonably good potential for geothermal; the potential geothermal provinces can produce 10,200 MW of power. However, with increasing environmental problems with coal based projects India will need to start depending on clean and eco-friendly energy sources in future; one of which could be geothermal. India occupies15 th position in geothermal power use by country. India has huge potential to become a leading contributor in generating eco-friendly and cost effective geothermal power. Around 6.5% of electricity generation in the world would be done with the help of geothermal energy. But, the power generation through geothermal resources is still in nascent stages in India. Geological survey of India has identified about 340 geothermal hot springs in the country. Most of them are in the low surface temperature range from 37^0-90^0 C which is suitable for direct heat applications. These springs are grouped into seven geothermal provinces i.e. Himalayan (Puga, Chhumathang), Sahara Valley, Cambay Basin, Sun-Narmadha-Tapi (SONATA) lineament belt, West Coast, Godavari basin and Mahanadi basin. Some of the prominent geothermal resources include Puga Valley and Chhumathang in Jammu, Manikaran in Himachal Pradesh, Jalgaon in Maharashtra and Tapovan in Uttarakhand. A new location of geothermal power energy has also been found in Tattapan.

Fig.8. Upcoming geothermal plant operate by NTPC in chattisgarh

In addition, Gujarat is set to tap geothermal electricity through resources which are available in Cambay between Narmadha and Tapi river. Puga, which is located at a distance of about 180 KM from Leh in the Ladakh region of Jammu and Kashmir across the great Himalayan range, is considered to be a good potential of geothermal energy. In Puga Valley, hot spring temperatures vary from 30^0C-84^0C (boiling point at Puga) and discharge up to 300 litres/minute. A total of 34 bore holes ranging in depths from 28.5 m-384.7 m have been drilled in Puga Valley. Thermal manifestation comes in the form of hot springs, hot pools, Sulphur condensates, Borax evaporates with an aerial extent of 4 Km. The hottest thermal spring shows a temperature of 84^0C and the maximum discharge from a single spring is 5 liters/second. Chhumathang spring is another geothermal area located about 40 Km north of Puga. The thermal water from Chhumathang is quiet similar to the thermal waters at Puga except the difference that its water has relatively higher Ph and Sulphate. Geothermal activity at Manikaran occurs in the form of hot springs over a distance of about 1.25 Km on the right bank of Parvathy river with the temperature range of 34^0C-96^0C here as on the left bank over a distance of about 450 m with the temperature range of 28^0C-37^0C. At Tapovan geothermal area, the highest temperature recorded is 65^0C. The discharge from the spring varies between 0.83-9.2 litres/second. Similarly, Tattapani is a promising geothermal resource in Peninsular India. Thermal manifestation at tattapani is very intense in an area of 0.05 sq.Km with several hot spots, hot water pools and marshy land. The surface manifestations show accurance of white to dirty white deposits identified as Sillica and moderate to low sag activity. Sixty thermal water springs occur at 18 localities in the West Coast hot spring belt. . Geothermal energy generally involves low running cost since it saves 80% of costs over fossil fuels and no fuel is used to generate the power. Since,no fuel is requires so costs for purchasing, transporting, cleaning plants is quite low

IV. CONCLUSION

1. The renewable energy scenario in India shows a growing trend. Developing countries relay heavily on conventional fuels, especially non-renewable energy sources such as petroleum or coal to generate power.
2. Renewable energy sources, which also are clean and environmentally sound. India has taken many steps in this regard and realised this at an early stage. Incorporation of renewable energy in to the system also means decentralised energy generation, which would facilitate quicker rural electrification. It would also be possible to electrify remote zones, which cannot be connected to the main grid.
3. The main focus, if renewable energy is to largely replace conventional sources in the future is that ways and means have to be found to make the technology far more efficient and capable of producing more power. The government is already financing entrepreneurs to set up renewable energy plants such as biogas plants, small hydro etc. It is also promoting and enhancing the development of cogeneration plans, which are essential in production of electricity from bagasse (waste from sugar mills).
4. Many policies and laws have made it easier for this alternate energy industry to flourish the ministry, along with its renewable energy agencies plays a large role in subsidising and financing renewable. Once the technology is cheaper and capital costs come down, the future for renewable energy is limitless.
5. Renewable forms of energy (especially solar and wind) could enhance energy security and represent a bright spot in its economic and environmental future. If India switched from coal, oil, natural gas and nuclear power plants, it is possible that 70% of the electricity and 35 %of its total energy could be derived from renewable resources by 2030.
6. India can ramp up its efforts to develop and implement large utility-scale solar energy farms to meet the country's economic development goals, while creating energy independence and bringing potentially enormous environmental benefits. Both issues have a direct influence on national security and the health of Indian economy.
7. Supplying almost 100% of India's energy demand through the use of clean renewable energy from solar, wind, hydro and biogas, etc. By 2050 is technically and economically feasible. The government of India target for renewable energy generation of 175 GW by 2022. We have got off to a good start with nearly 12 GW likely to be installed by 2016, more than 3 times the current capacity.

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