



DEVELOPMENT OF RENEWABLE ENERGY IN INDIA AND CHINA

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Abstract— This paper represents to compare the renewable energy development in countries represented by India and China. Both countries have committed to reduce their emissions through the increased use of renewable energy. This paper firstly explains the major renewable resources used in both countries. Then, the governance structure and policies in both the countries; the paper also compares the land availability and its use for the development of renewable energy resources. The various energy resources used in both the countries for generating the electricity is also explained. The current status of renewable energy resource development in two countries is described. From this study it can be concluded that both countries have set a renewable energy targets to enlarge the scale of renewable energy. However, renewable energy certificate mechanism is implemented more effectively in china than India.

Keywords— Renewable energy, India, China, policy, landscape

I. INTRODUCTION

In 2014, renewable energy provided an estimated 19.2% of global energy consumption. Power generation by using renewable energy resources is increasing day by day because of following reasons:-

- 1) Renewable energy resources are inexhaustible.
 - 2) Continuous fluctuation in the prices of fossil fuels and their limited resources are still dominating the world's economy.
 - 3) Green energy generation has to be increased to tackle the global warming scenario.
- Increasing energy demand, security of energy supply and reduction of emissions are the essential challenges for the world. [1] Energy consumption which accounts for 60% of global greenhouse gas emissions has mainly contributed to climate change. It is necessary to fight climate change and global warming while satisfying the world's energy consumption, without impairing the global economy is an urgent problem for every country. Reduction of CO₂ emission is important for dealing with climate change in the future. Renewable energy is an one of the best way to satisfy energy consumption without environmental degradation. Many countries' government have

committed to decreasing their emissions and respond actively through promoting renewable energy. Therefore, in recent years there are different types of policies to encourage renewable energy development not only in developed countries, but also in developing countries. There were 144 countries which had made different renewable energy targets and policies to support renewable energy development at the national level. In recent years, renewable energy has increased strongly in both developed countries and developing countries.

II. MAJOR ENERGY RESOURCES USED IN INDIA AND CHINA

As we know, China is the largest energy consumer in the world. Reduced amount of fossil fuels on earth will increase the use of Renewable energy resources for the energy generation. China is one of the leading country that pursuing the alternating energy sources. Currently, hydro, wind and solar energy are major sources of alternative energy in China. Due to environmental concerns, China has continued to pursue a vigorous renewable – energy - centered economic policy. The national Renewable source is long term sustainable solution. The national Renewable energy targets of China is 15% of RE by 2020 and 80% of RE by 2050.

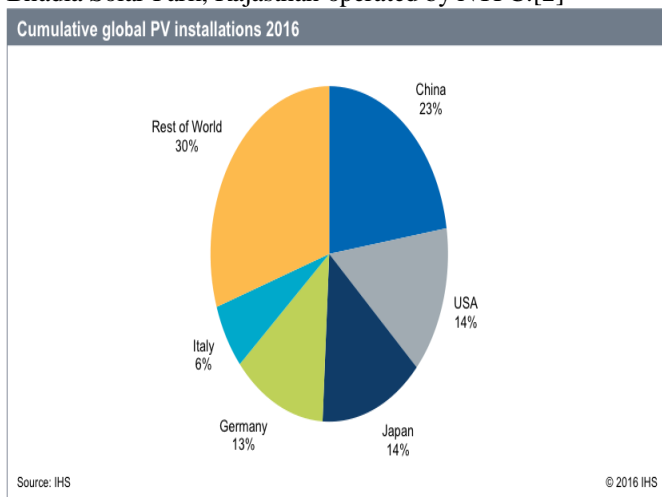
Wind, Solar, Hydro & Biomass are the various available renewable sources in India. A reliable nonconventional geothermal source is available in India but it is restricted to direct heat applications. This study shows the status of renewable alternatives in India. India is the 5th largest energy generation country and 6th energy consumption accounting for the global energy consumption. The renewable contribution of the total installed capacity of the India is about 11%. The national Renewable energy source targets of India is 15% of RE by 2020.

A. Solar Energy -

Solar photovoltaic energy is the free & continuous source of energy available on the earth. China produces 63% of the world's solar photovoltaic (PV). Many areas in China, such as Tibet, Xinjiang, Qinghai, Gansu, Ningxia and Inner Mongolia are the very good suppliers of solar energy with annual solar radiation of more than 1750 kWh/m². By the end of March 2015, China had total installed capacity of 33.12 GW of solar power with recent announcements that a target of an additional



15GW of solar power to be installed in future. In China there are large PV plants including Golmud solar park having capacity of 200 MW. There are a total of seven concentrated solar power projects (CSP) in China. One of which is expected to become operational in 2017 while 100 MW and 50 MW of parabolic trough CSP and tower plants are respectively being planned. Solar power in India is a fastest developing industry throughout the world. From September, 2017 the country's solar grid had a cumulative capacity of 16.20 GW. India increased its solar-generation capacity from 2,650 MW on 26 May 2014 to 12,289 MW on 31 March 2017. India's initiative of 100 GW of solar energy by 2022 is an ambitious target, since the world's installed solar-power capacity in 2014 was 181 GW. India is developing off-grid solar power for local energy needs. Fastest development of solar power projects is takes place at Rajasthan, Tamilnadu, Gujarat and Maharashtra. The largest solar projects having capacity of 2255MW is at Bhadla Solar Park, Rajasthan operated by NTPC.[2]



global pv installation 2016[12]

B. Wind Energy

The wind energy potential in China is considerable, according to the 3rd national wind energy resource survey organized by the China Meteorological Administration; the exploitable wind energy potential is 600–1000 GW onshore and 400–500 GW offshore. In 2016, China increased 19.3 GW of wind power generation capacity to reach a total capacity of 149 GW, and generated 241 TWh of electricity, representing 4% of total national electricity consumption. Despite the recent rapid growth rates of wind power in China, the distribution is uneven and not matched with economic development. Goldwind from Xinjiang province is the largest domestic wind turbine manufacturer. Wind power generation in India has significantly increases in recent years. At end of July 2017, total installed capacity of wind power is 32.56 GW. India has 4th largest wind power installed country.[2] The largest development of the wind energy in India takes place at Maharashtra, Madhya Pradesh, Kerala, etc.

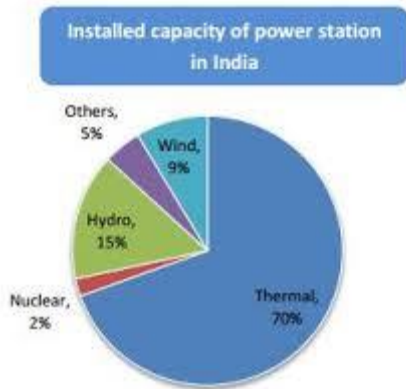
C. HydroPower

Nowadays,Hydropower is the leading renewable source for electricity generation globally. It supplies 71% of all renewable electricity. Reaching 1,064 GW of installed capacity in 2016, the generating capacity is of 16.4% of the world's electricity from all sources. Global generation of hydropower rises, with China retaining the global lead; climate risk remains a pressing concern for the industry. At the end of 2015, China, the US, Brazil, Canada, India and Russia are the leading hydropower generating countries[6]. Nowadays, Hydroelectricity is China's largest renewable energy source and the second overall after coal. The installed capacity of China in 2015 was 319 GW, up from 172 GW in 2009, including 23 GW of pumped storage hydroelectricity capacity. In 2015, hydropower generated 1,126 TWh of power, accounting for roughly 20% of China's total electricity generation. Whereas ,India is the 7th largest producer of hydroelectric power in the world. As of 30 April 2017, the total installed capacity of hydroelectric source in India was 44,594 MW, or 13.5% of its total utility power generation capacity. India is economically exploitable and viable hydroelectric potential;which estimates to be 148,701 MW. The hydroelectric power production in India accounts 92.5 % for the public sectors. As India is an agricultural country, Pumped storage units can also be used for pumping stations to supply river water for irrigation, industrial needs, and drinking water.

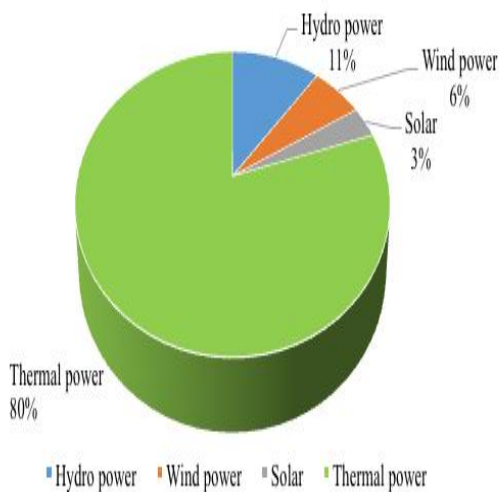
D. Biomass Energy

India is very rich in biomass. India has a potential of 19,500 MW in which 3,500 MW from bagasse based cogeneration and 16,000 MW from surplus biomass. Recently, India has 537 MW commissioned and 536 MW under construction. The facts strengthen the idea of a commitment by India to develop these resources of power production. States including potential for biomass energy production are Andhra Pradesh(200MW), Bihar(200MW), Gujarat(200MW), Karnataka(300MW), Maharashtra (1000MW), Punjab(150MW), Tamilnadu (350 MW), and Utter Pradesh (1000MW). Biomass may be used in number of ways to produce energy. The most common methods are Combustion, Gasification, and Fermentation & Anaerobic digestion. The sustainable biomass resource available for energy use can be divided into five categories: agricultural residues, forest residues, biomass production on surplus degraded land, organic wastes, and others. It is concluded that biomass can directly substitute fossil fuels, as more effective in decreasing atmospheric CO₂ than carbon sequestration in trees. The Kyoto Protocol inspires further use of biomass energy. It is estimated that biomass will contribute somewhere between 15% and 50% of the world's primary energy consumption by the year 2050. China is rich in biomass resources. The annual available amount of agricultural residues throughout the country is equivalent to 440 million tce. by the end of 2014, the installed biomass

capacity only reached 14.23 million kilowatt of electricity and the parallel part was 9.49 million kilowatt.[12] Based on abundant biomass resources, China's biomass power generation industry develops rapidly.



installed capacity of India [11]



installed capacity of China [9]

III. GOVERNMENT ENERGY POLICIES

The approach system is the significant factor to the accomplishment of sustainable power source in any nation. Vitality approach must make a harmony between alternatives of vitality supply and of interest side vitality effectiveness that gives vitality administrations. The fundamental function of approach and administrative system is to make strong motivating force structures which brings issues to light for lifecycle cost (LCC) examination and empower great practice tasks and developments to turn into the market standard. The general advancement and advancement of sustainable power source innovations (RETs) and its applications can

accomplished by this approaches. Arrangement activities rouses private segment to participate in inexhaustible business according to arrangement of monetary and money related motivators for a wide scope of sustainable power source (RE) programs. Approaches are to a great extent budgetary, financial impetuses or unique orders intended to moves or offers lift to utilities to purchase RE control, advertiser organizations to set up RE ventures, hardware organizations to produce RE gear or private and government substances to attempt R&D identifying with RE.

1. Vitality approaches utilized in India

At the focal level, approach measures are regulated through the Ministry of New and Renewable Sources (MNRE) in India.[3] The state governments contribute by making accessible infrastructural offices for wheeling of vitality and purchasing vitality from sustainable units. A portion of the approaches and monetary motivating forces in India for Renewable vitality assets are talked about underneath:

A. Remote venture approaches

The Government of India urges remote speculators to set up RE-put together power age ventures with respect to Build, Own and Operate (BOO) premise. Government additionally urges remote speculators to set up control ventures dependent on other nonconventional vitality sources moreover. As per strategy, control buy concurrence with the concerned state government is required to enter the speculators. For monetary as well as specialized coordinated effort Foreign speculators can go into a joint endeavor with an Indian accomplice for setting up of RE-based power age ventures. To set up a mechanical endeavor with Foreign Direct Investment (FDI) by Non-Resident Indians (NRIs) no endorsement of government is required.

B. Remote speculation execution authority (FIIA)

The FIIA has been set up in the Ministry of Commerce and Industry to interpret FDI endorsements and executions. It is going by the Secretary (Department of Industrial Policy and Promotion) and is adjusted by the SIA. FIIA would give a one-stop after-care administration to remote speculators by helping them to speed up endorsements and clearances and to sift through operational issues with other government offices. It is single-point interface between the speculators and government offices including authoritative services, state governments, Pollution Control Boards, Directorate General of Foreign Trade, administrative specialists, charge specialists and Company Law Board and so on. The endorsement holders have been mentioned to connect with particular officials in FIIA. Subsequently the arrangements in FIIA are legitimately or in a roundabout way connected with sustainable advancement.



C. Industrial arrangements

In mechanical approach, MNRE is advancing medium, little, smaller than normal and miniaturized scale endeavors for assembling and adjusting of different sorts of RE frameworks and gadgets. For setting-up of a RE industry, mechanical clearances just as no freedom is required from Central Electricity Authority (CEA) for control age extends up to Rs 1,000 million. For RE control age ventures government is permitted multiyear charge occasion and for RE hardware producing, Soft credits are accessible through IREDA. Financial help is additionally accessible to RE enterprises for R&D extends in relationship with specialized establishments.

D. Joint Ventures Policies

Joint ventures are a financial as well as technical Collaborations and they are used by foreign investors as it provides maximum visibility and presence in the country. An outside speculator can go into a joint endeavor for assembling RE items and frameworks, yet in addition in RE-based power age ventures.

2. Energy policies used in China

China's approaches on sustainable power source advancement fall into three classes. China's focal government sets up the initial two degrees of approach. Neighborhood governments, including commonplace, metropolitan, and area governments, set up the third degree of approach with generally speaking bearing from the focal government.[4]

First-level approaches: give general course and direction, and incorporate addresses of state pioneers about advancement of sustainable power source and the Chinese government's point of view on the worldwide condition.

Second-level approaches: determine objectives/targets and advancement plans, and spotlight on provincial jolt, sustainable power source based age innovations and fuel wood. These strategies endeavor to institutionalize the headings, central focuses, and goals of sustainable power source advancement from various perspectives. A few offices propose solid arrangements and guidelines. Second level approaches have assumed a significant job in advancing inexhaustible advancements in China.

Third-level strategies: comprise of down to earth and explicit impetuses and administrative rules. These framework explicit supporting measures for creating and utilizing sustainable power source. These third-level government approaches give significant help to help create sustainable power source in its initial development stages. Since the mid-1990s, numerous areas and self-ruling districts of China have received approaches for creating sustainable power source, including

appropriations and expense decrease. The focal government additionally gave a few successful guidelines [8]

Comparison key between India and China :

Indicators	India	China
Size of population	1.1 billions	1.3 billions
Type of Government	Democracy	Communist State
GDP growth rate(2016)	5.7%	6.8%
Renewable Energy Target	Renewable energy targer(RET) 15% of RE by 2020 175GW by 2022	Renewable Energy Law (REL) 80% of RE by 2050 154GW by 2020
Relevant Government authorities	Federal government, state government and local government	Central government , provincial government and local government

IV. ENERGY LANDSCAPE

Sustainable power source innovation improvement and assembling likewise give clear chances to the Chinese focal government to advance a household innovation producing base, and to accomplish China's 2020 vitality age focuses, as will be demonstrated as follows. In this way, sustainable power source innovation will assume an undeniably significant job in China's vitality scene. Right now, the scene of Indian ER&D foundations has huge number and assorted variety of associations govt., open segment, and private part are engaged with vitality related R&D in India. India has vitality related R&D over a colossal scope of territories, for example, sunlight based photovoltaic modules, power devices, biomass gasification, propelled coal advancements, car innovations, railroad motors, oil investigation and refining, atomic vitality, and so forth. Simultaneously, explore uncovers that the Chinese sustainable power source innovation advertise presents a Catch 22: a market of chance dependent on a requirement for the improvement of creating limit from



inexhaustible sources, combined with the presence of strategy, monetary, and mechanical obstructions which hamper the capability of China's cleantech showcase in sustainable power sources. China is delineated as a main cleantech advertise in the short to medium term, particularly in sustainable power source innovation, venture foundation, and assembling.

1) Energy landscape in china :

Vitality scenes can be lopsided scenes in china. This can be because of an assortment of elements. Be that as it may, most importantly, the presence of deterrents to the improvement of cleantech scenes in a national setting can generally be identified with approach, monetary, and financial issues which can be profoundly nearby. Simultaneously, China's cleantech scene, and explicitly its sustainable power source showcase, is a case of the interchange of these powers. The accompanying features a portion of the primary issues confronting the sustainable power source advertise in the nation today, concentrating on vitality valuing approach, innovation move, private venture, and the requirement for accentuation on vitality preservation just as observing and assessment.[12]

- Pricing policy short forms :

China's 2006 Renewable Energy Law points are to expand the limit produced from renewables in the nation, and are a piece of a more extensive national methodology planned for expanding power supply just as differentiating the creating base, because of rising interest and a requirement for vitality security.⁸ The law's sustainable power source valuing components depend on "feed-in" levy models of the sort applied to European vitality markets. Hence, the current sustainable power source scene—particularly on account of wind control—includes an overabundance of finished undertakings which are not really associated with the lattice.

Technology transfer : uncertainty over import factors

Vulnerability likewise exists over the strength of China's present import obligations on sustainable power source innovation and related machine segments. This vulnerability is a particularly significant factor in hampering previously settled advancements like breeze turbines. The Chinese government's import obligation procedure for wind innovation has changed generally since the beginning of enormous scale wind age in 1986, on the other hand forcing high and for all intents and purposes non-existent assessments. Vulnerability stays over the shakiness of import obligations and different assessments on remote innovation import. With the focal point of building wind ranches with a creating limit of at least 100 MW, the subsequent moving import obligation and duty scene isn't helpful for straightforward cost estimating for merchants, local producers and, undoubtedly, wind venture designers.

Private investment shortfalls :

Private speculation has become the transcendent power in wind ranch development in different nations. Around ninety-

five percent of interest in wind ranches was contributed by the private segment in India. Except if another venture system with impetus strategies and guidelines is set up in China, and progressively budgetary channels are opened up, it will be hard to understand the objective of wind vitality improvement.

2) Energy landscape in india

The scene of Indian ER&D establishments and their exercises talked about above is described by various highlights:

- A large number and assorted variety of associations govt., open area, and private division are engaged with vitality related R&D in India. This fairly rich assorted variety of association and the scope of their exercises separate India from most other creating nations. [5]

- Public division establishments unmistakably overwhelm ER&D endeavors in India with private area firms assuming a critical job in a couple of segments. Prominently, however, the job of scholarly establishments appears to be generally minimal (in spite of the fact that somewhat this recognition is an element of the incredibly constrained information accessible). To be reasonable, this ought not be excessively astonishing since a considerable lot of these scholarly foundations center around fundamental research, similar to the case in different nations. Some scholastic R&D programs are profoundly applied, however, and have indicated a lot of accomplishment, for example, the biomass gasifier program at the Indian Institute of Science examined before.

- India has vitality related R&D over a colossal scope of zones, for example, sun based photovoltaic modules, power devices, biomass gasification, propelled coal innovations, car advances, railroad motors, oil investigation and refining, atomic vitality, and so forth.

- A modest number of associations command the national ER&D scene, representing a generous segment of vitality significant R&D spending. This incorporates BHEL, IOCL, ONGC, and SAIL in the open segment, DAE and CSIR among the administration organizations, and TELCO and BAL inside the private segment.

- Generally the all out ER&D consumptions in India are very low contrasted with uses in industrialized nations, which is not out of the ordinary given India's restricted budgetary assets. the vitality part has gotten just negligible consideration inside the S&T foundation in India, particularly in the arranging procedure. Vitality important R&D is frequently subsidized in various organizations, yet without express thought of how a specific undertaking fits into India's vitality future.



Indeed, the nation doesn't have a vital arrangement for innovation advancement in connection to India's vitality future, prompting piecemeal endeavors that don't really have cooperative energy between them. In this way, a generous and coordinated exertion will be required to fittingly reorient and fortify India's ER&D abilities to meet the vitality and ecological difficulties confronting the nation.[10]

V. THE STATUS OF RENEWABLE ENERGY DEVELOPMENT IN INDIA AND CHINA

China and India are driving nations in this worldwide clean vitality upset. While there are noteworthy increases happening wherever I the world, China is a commanding power on the sustainable power source front. Besides, the nation has made significant walks in starting a notable move away from coal. There's clearly far to go to make the profound cuts in CO₂ discharges in accordance with the long haul objectives of the Paris Agreement yet this is a promising beginning.

Here are some ongoing realities:

- In January, China summed an arrangement to put \$360 billion in sustainable power source through 2020, with an objective of making 13 million employments. [7]
- The thirteenth multiyear plan, covering 2016-2020, additionally sets aggressive focuses for non-fossil limit: By 2020, the nation hopes to introduce 340 GW of hydropower, 200 GW of wind, 120 GW of sun oriented power, just as 58 GW of atomic limit and 25GW of biomass.
- China has as of late dropped over a hundred proposed coal terminated power plants totaling 120 GW.
- China has additionally allotted \$14.5 billion to help progress dislodged laborers to new openings, in spite of the fact that it's too soon to tell how fruitful those endeavors have been to date.
- Data shows that china's coal utilization has likely crested, adding to 4 years of level or somewhat falling vitality related CO₂ emanations.
- A late examination from atmosphere
- Action
- Tracker shows that with the moves it has just made, and has focused on taking sooner rather than later, China is on track to meet or even surpass its broadly Determined Contribution under the Paris Agreement.

Then, in India, an ongoing report focuses on that a memorable change of intensity area is now in progress. While coal still rules India's capacity supply and considerably more will be expected to drive down carbon outflows over the economy, here are a few purposes behind confidence:

- India's 2016 Draft Energy Plan incorporates an objective of 175 FW of sustainable power source limit by 2021-22, up from around 43 GW as of now.
- India's Jawaharlal Nehru National Solar Mission expects to introduce 100 GW of sun oriented limit by 2022.
- Equally significant, through a blend of arrangements, this current activity's objective is likewise to forcefully cut down the expenses of sun based capacity to accomplish lattice

equality in that equivalent time allotment. On the off chance that that objective is met, it has immense ramifications for the reasonableness and increase pace of sun oriented power in India as well as world - wide.

- The Draft Energy Plan likewise presumed that no new coal terminated power plants would be required through 2027, past the 50 GW right now under development. Truth be told, simply a month ago India dropped about 14GW of proposed coal terminated power plants, and found that 8.6 GW of existing coal terminated power plants may never again be monetarily suitable.
- India is likewise definitely inspired by electric vehicles, investigating choices to completely zap vehicles by 2032. Its extreme thought, with a great deal of difficulties isn't an official government objective (yet). Be that as it may, the energy and enthusiasm for clean development is obvious.

- Analysis from the Climate Action Tracker additionally shoes that India is on track to surpass its present Paris Agreement responsibilities, with space to raise aspiration on the off chance that it picks.

VI. CONCLUSION

Improvement of sustainable power source is the suitable alternative to meet the expanding vitality utilization and decrease carbon outflows successfully in both created and creating nations. The two India and China sets sustainable power source focuses to augment the size of sustainable power source application presenting arrangements and guidelines at national and state level, executed diverse government programs and gave motivating forces and subsidizing to guarantee their objectives can be met in required time. The two nations are driving players in this worldwide clean vitality upset. China is the biggest vitality purchaser on the planet and it is positioned third in creating influence from wind vitality sources, while the India is exceptionally wealthy in biomass creation and sunlight based vitality age as it is a rural nation.

China's approaches on sustainable power source advancement fall into three classifications. Neighborhood governments, including commonplace, city, and area governments, set up the third degree of approach with generally speaking course from the focal government. In India, at the focal level, arrangement measures are managed through the Ministry of New and Renewable Sources (MNRE).

The scene of Indian ER&D foundations has large number and assorted variety of associations govt., open division, and private segment are engaged with vitality related R&D in India. India has vitality related R&D over a gigantic scope of zones, for example, sun oriented photovoltaic modules, power modules, biomass gasification, propelled coal advances, car advances, railroad motors, oil investigation and refining, atomic vitality, and so on.



LIST OF ACRONYMS:

BHEL	Bharat Heavy Electrical Limited
CSP	Concentrated Solar Power
CEA	Central Electricity Authority
CSIR	Council of Scientific and Industrial Research
DAE	Department of Atomic Energy
ER&D	Engineering Research and Development
FIIA	Foreign Investment Implementation Authority
FDI	Foreign Direct Investment
IOCL	Indian Oil Corporation Ltd
MNRE	Ministry of National Renewable Energy sources
NTPC	National Thermal Power Corporation Ltd
NRI	Non Resident Indians
ONGC	Oil and Natural Gas Corporation
R&D	Research and Development
SIA	Security Industry Authority
SAIL	Steel Authority of India Limited
TELCO	Tata Engineering and Locomotive Company

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