# Patratu Vidyut Utpadan Nigam: A Unique Model of Project Execution

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## ABSTRACT

*PatratuVidyutUtpadan Nigam (PVUN),ajoint venturebetween Indian power conglomerate NTPC Limited and the Jharkhand state of India, was set upfor capacity addition of 4000MW besides performance improvement of the erstwhile Patratu Thermal Power Station (PTPS).Capacity addition was planned in two phases; Phase-I of 2400 MW and Phase-II of 1600 MW. PVUN was given three additional responsibilities. First, to identify, collect, and dispose-off more than ten thousand tons of metallic and non-metallic scrap scattered inside the plant. Second,to evaluate, dismantle, and dispose ofthe existing ten units of PTPS in order to make space for Phase-II of capacity addition.Third, to develop a coal mine for meeting fuel requirementsof the new projects.*

*Setting up thermal power plants has been a routine for NTPC. It has set up many such projects comprising generating units of variouscapacities. It has also developed one coal mine at PakriBarwadih from which commercial production has started recently. NTPC has always promoted environmental protection. But, stringent environment protection norms combined withfour diverse projects, including disposal of thousands of tons of waste material which consists hazardous waste as well, make the task of environment protection more challenging for PVUNL.*

*How PVUN would manage to execute this model project in view of so many other interlinked responsibilities? What are its strategies for project management which would make it a unique project? Can it set benchmarks in safety, environment, and CSR practices?*

**Keywords:** Project Management, Strategic Management, Thermal Power Plant

## 1. CASE FOCUS: GENERAL MANAGEMENT, PROJECT MANAGEMENT, ENVIRONMENTAL MANAGEMENT

It was quite a hectic day for Mr.SudarsanChakrabarti who had come to Patratu to join PatratuVidyutUtpadan Nigam (PVUN) as its Chief Executive Officer (CEO). Early morning he had left New Delhi,the capital city of India, to reach Ranchi, the capital city of Jharkhand for onward journey to Patratu. Chakrabarti had spent over thirty years of his career in New Delhi. Jharkhand, a tribal state of India which is rich in natural resources and needs development on all fronts including the energy sector, was challenging for him. Having landed in Ranchi, while

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descending the serpentine roads of Patratu Hills, he recalled his days in the Engineering department of the NTPC'scorporate office. His role as a system designer would now change to the role of an executioner of the design. At the corporate office he had come across the words "Patratu Model" quite often. The term was quite intriguing and now he has to lead a team of professionals who would not only develop "Patratu Model" but would also execute it to set a benchmark for others to follow. It is an all-inclusive model of most modern thermal power plant with concept to ideal commissioning philosophy. He was briefed that Patratu Thermal Power Station (PTPS) used to be the main source of energy for the state of Jharkhand. Its operation was discontinued due to environmental and techno-commercial reasons. Now, all eyes are on PVUN, which was in early stage of re-construction, to start power generation.

Amidst rising concerns of environmental protection, coal-based thermal power plants have been termed as the largest source of carbon dioxide, a greenhouse gasthat leads to global warming. Still almost forty percent of world energy is generated using coal(Flisowska, Kalaba, Gunduzyeli, 2019). Coal, which is the fuel for such power plants, harms environment from the stage of production to the final stage of disposal as residual ash. As per the report of Business Standard News (03.04.2019), 1.2 million Indians died due to air pollution in 2017. Subsequent to Paris convention, 2015, most of the countries have started reducing coal-based power generation, some European countries like Germany, France, and England have even started living without coal-based power generation (Dapsevitch, 2019). Thus, Chakrabarti's greatest challenge was to tackle environmental concerns? What would be his plans to address the environmental concerns while disposing of thousands of tons of hazardous materials like sludge of burnt fuel, acid, alkali, batteries, coal in mill bunkers, used turbine oil, other chemicals? How would he meet the environmental challenges in development of the coal mines? The project engineering, which used to be done from NTPC Corporate office, was to be done from Patratu site. Tomeet the project milestones under the new system was yet another daunting task for him.

## 2. PVUNL

The Indian state of Jharkhand was created in the year 2000. Since then a need was felt to improvethe power generation capacity of the state to bridge the gap of energy deficit created by the faster pace of growth, industrialization, and rise in household energy demand. It was looking for a reliable partner to turn around the power scenario in the state.

After years of negotiations with NTPC Limited, the agreement for the formation of a JV was signed on 29th September 2015 and it was incorporated on 15th October 2015 (Gauba, 2015). PatratuVidyutUtpadan Nigam (PVUN) Limited, with NTPC and JBVNL having stakes of 74% and 26% respectively, was, thus, created (Biswas, 2016). The JV was formed with specific three targets. The first target was to improve the performance of two operating units (Unit #6, 10) of Patratu Thermal Power Station (PTPS); all the generating units of erstwhile State Electricity Board, put together, were producing only about 100 MW against 840 MW capacity. The second target was to revive the operations of the three closed generating units (Unit#4, 7, 9) of PTPS.The third target was to add 4000 MW capacity in two phases (Phase-I of 2400 MW and Phase-II of 1600 MW). Assets of PTPS were physically transferred to PVUN on 1st April 2016 (Biswas, 2016). These assets

comprising of PTPS plant, machinery, equipment, the scrap lying inside the plant premises, the inventory lying in the stores, and 1234 acres of land entitled the Government of Jharkhand (GoJ) to hold a stake of 26% in the JV in a cashless transaction.

GoJ is represented in the JV by Jharkhand BijaliVitaran Nigam Limited (JBVNL). JBVNL is the energy distribution arm of Jharkhand State Electricity Board (JSEB). NTPC Limited is the largest power producer in India. It has 55126 MW power generating capacity comprising of thermal,hydel, solar and wind energy. Through forward and backward integration, NTPC has expanded into the fields of coal mining, electric equipment manufacturing, consultancy, and many other related areas.

As its first task, PVUNL started the work of performance improvement of the generating units by incorporating better operation and maintenance practices. Frequent tripping of Unit#10 was reduced, its operating parameters were improved, and plant loading factor (PLF) improved. Unit#6 which was operational at the JV formation stage but had to be shut down due to a major maintenance problem.Though there were no drawings, documents or O&M manuals available for reviving the units, due to the expertise of NTPC executives deputed in PVUNL, it was possible to revive its operation. Out of the closed units,Unit#4did not need much investment so it was brought back to service. Unit#7 & 9 needed huge investments.

As PVUNL had funds crunch, it was decided to take up therevival of other units after stabilizing operations of Unit#4, 6 and 10 (Kayasth&Sahay, 2017). Thenon-payment of energy bills, stringent environmental norms set for the coal-based thermal power plants (Exhibit - 1), and non-viable techno-commercial operating conditions of the existing plants resulted in the JV taking a strategic decision to close down all the units. This was in pursuance to the Paris commitment by the Government of India (GoI) and policy statement by the GoI in the Indian parliament on 20$^{th}$ July 2017 (Mondal, 2016, Reuter, 2017,Energyworld, 2017). As perGoI policy decision,all coal-based thermal power plants older than 25 years were advised to be shut down on account of poor efficiency and operability. This resulted in the closure of all the units of PTPS. The JV, thus, had to change its gears; instead of performance improvement, its priority now became setting up of the Phase-I of the new project (Kayasth&Sahay, 2018).

Chakrabartihas been with NTPC Limited for over 30 years. Before joining as CEO of PVUNL, he was a General Manager (GM) inthe Engineering Department of NTPC. He has been the part of engineering/task force teamformany projects of NTPC Limited. At PVUNL, he faced gigantic task of adding 2400 MW of thermal capacity as phase-I expansion project but for this he needed space and therefore, had to disposeoff thousands of tons of scrap accumulated over the years, lying helter scalter in PTPS plant premises. The scrap included environmentally hazardous materials like sludge, coal waste,used lubricants, used batteries, e-waste, used conveyor belts, and many other hazardous materials. After shut down of the plant operations, spares of the plant and machinery became surplus. These inventories, too, lay stored in forty-five godowns, open yards, site stores. These store items also included hazardous materials acid, alkali, light diesel oil (LDO), heavy furnace oil (HFO), batteries, PVC items, tyres, lubricants, conveyor belts, etc. The area occupied by scrap and store items was to be vacated at the earliest to make space for the 3*800 MW expansion project. Disposal of these scraps and inventories, therefore, became the first priority.

Further, retired generating unit#1 to 10 of PTPS needed to be dismantled to make way for phase-II of the expansion project (2*800 MW) of PVUNL. NTPC, so far, had only added generating capacity but this exercise of dismantling the retired units was to be carried out for the first time. Besides the safety concerns, disposal of coal from the coal bunkers, lubricating oil remained in the equipment, glass wool used for insulation, debris likely to be generated in the dismantling operation posed an environmental hazard. In addition, the 3*800 MW project needed to cut some of the trees to clear that area; getting permission to cut trees was a nightmare. Chakrabarti had to tackle all these issues diligently with the help of his team at Patratu.

## 3. ENVIRONMENTAL ISSUES AT PVUNL

United Nations Development Programme (UNDP) resolved for sustainable development by bringing out the Global Sustainable Development Report (GSDR) in 2015 (Exhibit-3). This was adopted by nations across the globe. Indian policies have to be aligned with these guidelines. Accordingly,the Ministry of Environment and Forest (MoEF), Ministry of Power, and the individual companies design their environmental policies. NTPC, the leader in the area of power generation in India, has taken various measures for mitigation of environmental pollution due to power generation so that harmony between man and environment is maintained. PVUNL, being the subsidiary of NTPC, has the environment policy in line with that of NTPC. The environmental issues can be checked as per different verticals at PVUNL as given below.

## 4. NEW PROJECT (PHASE-I: 3*800 MW)

GSDR mentions its sixth sustainable goal as "Ensure availability and sustainable management of water and sanitation for all". The Jharkhand state of India has a hilly terrain with only two main rivers named Damodar and Subernrekha. Patratu plant of PVUNL is designed to source water from Patratu dam. This source is being used also for supplying water to almost 1000 villages of Ramgarh district situated downstream. Hence judicious use of water isvery important.In order to conserve water, three major measures have been taken by PVUN. A zero liquid discharge (ZLD) policy has been adopted to minimize the makeup water requirement for the plant. Recycling of the drain storm and other wastewater has been envisaged. There is a plan to bring municipal wastewater from Ranchi through pipelines. This water may be used after recycling. PVUNL is going to be the second plant in India to use air-cooled condenser (ACC) to conserve water as compared to conventional cooling towers of thermal power plants having high evaporation loss. 840 MW plant of PTPS was using 30 cusec water whereas PVUNL phase-I of 2400 MW would have only 21 cusecsof water consumption.These measures are significant steps toward water conservation.

Sustainable Development Goal (SDG) 13 of GSDR, 2015 says "Take urgent action to combat climate change and its impacts". In order to minimize the air pollution caused by coal-based thermal power plants, several measures have been taken by the Government of India. Exhibit-1 shows that the flue gas emission norms have become stringent for thermal power plants. Exhibit-2 shows the amount of carbon dioxide emitted by different types of coalswhen combusted. Now flue gas can have suspended particulate matter (SPM) of 30 mg per cubic meter (N) as compared

to 50 allowed for machines installed before 2016. Likewise, emission norms for Sulphur oxides (SOx) have changed from 600 to 100; nitrous oxides (NOx) have changed from 300 to 100, however, mercury has remained at 0.03 mg per cubic meter (N). SOx causes acid rain; others may cause serious respiratory ailments. As per "State of Global Air 2019" report, in the year 2017, three million deaths were reported world over due to air pollution in which India alone had 1.2 million deaths (Business Standard News, 03.04.2019).

The power plant designed for PVUNL is based on ultra-supercritical technology with high pressure and temperature parameters of steam. This leads to the maximization of thermal efficiency and minimization of specific coal consumption. Hence, the coal consumed per unit of power generation will be minimized thereby minimizing the production of carbon dioxide and other emissions mentioned above. Coal burners have been designed to ensure a steady log mean density of coal air mixture distribution as it enters the combustion zone without allowing the coal dust to settle down. This ensures complete combustion of coal thereby reducing the specific coal consumption. Air to fuel ratio around the burner has been optimized to ensure low emission of NOx. Further, selective catalytic reduction (SCR) technology is being used to keep NOx emission well within the standard norm of 80 units.A highly efficient electrostatic precipitator (ESP) is designed to keep suspended particulate matters (SPM) well within the allowed limit of 30 units. Flue gas desulphurization (FGD) units have been incorporated in the plant design to keep the Sox emission well below the permitted limit of 100 units.

SDG15a talks of protection and restoration of terrestrial ecosystems, SDG15d talks of combating desertification. For setting up the new project it was necessary to clean up the area of all vegetation which included trees of all sizes. Necessary clearance was taken from the district forest office. Trees were classified into three categories depending upon theirdiameter at a height of one meter from the ground level. Those having a diameter less than four inches were permitted to be cut or uprooted. Those having a diameter between four inches to seven inches were to be transplanted. Transplanting such trees, almost a thousand in number, was a big challenge. These trees, mostly teak, had longitudinal roots. Protecting their roots while digging from the original location and planting at another location posed a serious threat to their survival. The challenge was to ensure ninety percent survival rate. Nowhere in India was transplantation done at this scale. Wherever transplantation was done, ensuring the required survival rate was a serious challenge. Neeraj Mittal, General Manager (Contracts & Materials) took this as a challenge. Many agencies were contacted but satisfactory response was not forthcoming. After months of search, deliberations, negotiations the deal was finalized with an agency (PVUNL, 2018) that transplanted the trees with Volvo transplanting machine (Exhibit – 4) and ensured survival rate of more than ninety percent. Trees with diameter more than seven inches were numbered. After inspection, the district forest officer (DFO) cleared them for cutting with a condition of developing a green zone. PVUNL promised to develop green zone within five years by planting at least ten times the number of trees cut to make way for the project. This way terrestrial ecosystem was protected and desertification was avoided. Additionally, land requirement has been minimized by adopting integrated compact design philosophy for all its systems and auxiliaries, including that of switchyard by using gas-insulated switchyard (GIS).

SDG15e talks of a check on land degradation to halt the loss of biodiversity.This condition poses a serious challenge to coal-based thermal power plants due to generation of bottom ash due to combustion of coal, and fly ash collected from the flue gas. As a normal practice in thermal power plants, ash is mixed with water to make a slurry and pumped to dispose at some distance known as ash-dyke. Ash may contain traces of lead, mercury, and arsenic which may contaminate nearby water bodies due to leaching. In order to avoid land degradation and to protect biodiversity, Chakrabarti emphasized developing ash mound in line with Dadri project of NTPC where beautiful gardens, parks, and pondshave been developed. Hundred percent disposal of dry ash was contemplated by providing ash brick plants, cement plants, landfilling in road constructions through National Highways Authority of India, and by filling exhausted open cast coal mines through Coal India Limited.

While extracting SOx from the flue gas, FGD is going to produce gypsum as a by-product. In order to avoid land degradation which may be caused due to its dumping, gypsum is planned to be used for manufacturing gypsum boards having wide industrial applications.

## 5. DISPOSAL OF SCRAP

The first unit of PTPS plant was commissioned in the sixties. Since then many renovations and modernization exercises were done. But the scrap generated over the years were not properly disposed-off. Thousands of tons of metallic and non-metallic scrap remained covered under tall bushes. At some places scrap was discovered after cutting the trees and cleaning of jungles.The scrap was to be sold by PVUNL and cash so obtained was to be adjusted against equity of JBVNL. Chakrabarti was in dilemma;whether to sell or to auction the scrap, how to select the auction partner. There were many options for offline as well as online auctions. After deliberating the issue with his team he decided to follow NTPC system and procedures for auction of the scrap. He also decided to follow all the guidelines promulgated by the Central Pollution Control Board (CPCB)at their disposal to protect the environment.

Incidentally,NTPC had an agreement with MSTC for the online auction of scrap items. Online transactions, where the trading platform is open to all registered vendors, are more transparent. Hence, MSTC was roped in to conduct auctions of different scrap materials. To ensure proper handling, storage, transportation, use, and disposal of the hazardous materials, terms, and conditions of the auction was modified to incorporate specific term and conditions.Only those vendors could participate in the auction who had permission from MoEF to handle the material under auction. This was very useful in disposing of LDO sludge, HFO sludge, used lubricant, used coolant, used tires, conveyor belts, caustic soda, sulphuric acid, burnt cables, and similar items in environment-friendly manner.

Neither Chakrabarti nor his team members had prior experience of dismantling coal-based thermal power plants. Retiring old thermal power plants was not his ball game. With full faith in the NTPC team having "Can Do It" attitude, he was confident of setting up new units but was anxious about quick and proper disposal of thousands of tons of scrap and retired plants which involved materials with potential environmental hazards.The first and foremost thing was to find out the appropriate process to carry out these operations.

For dismantling of the units, a cross-functional "Decommissioning" team was constituted. The question was whether to go for a new valuation of the plant or to rely on the plant valuation done during JV formation? It was essential to determine its value before starting dismantling. Whether an expert committee would valuate or a consultant should be hired? What should be the process of selecting the consultant?What measures need to be taken so that the whole process of plant disposal does not impact the environment adversely? How these measures could be enforced on the successful bidder so that all environment protection norms are complied with? These issues kept Chakrabarti troubling until he finalized a complete roadmap in consultation with his team and with the consent of the Board of PVUNL.

The team decided and obtained approval for the disposal of the units by the way of e-auction. PVUNL Board also decided to engage a leading engineering consultant to determine the new value of the whole plant (Unit#1 to 10) which would form the basis for the reserve price for the forward e-auction. The fresh valuation was necessitated because the earlier valuation was donewhen five out of ten unitswere in operation whereas now it can fetch onlysalvage value as all the units were declared as non-generating units (CEA, 2017). A committee finalized the terms and conditions of contract which would be binding on the successful bidder in order to comply with all environmental protection norms and industrial safety norms. After the auctioning of the plant the same would be dismantled within specific timeframe to make space for the phase-II of the expansion project (2*800 MW).

## 6. SETTING UP OF COAL MINE

Coal is the primary fuel forthe new 2400 MWproject being set up by PVUNL. Consumption of coal has been estimated to be thirteen million tons per anum(MTPA). After addition of 1600 MW in the second phase, the coal consumption will be in the range of twenty-two MTPA. It is worthwhile to have a permanent coal linkage with at least one coal mine. The state of Jharkhand has the highest coal reserve in India. Looking at the massive coal requirement, the Government of India decided to lease a coal mine to PVUNL. The allocated mine is located 110 Km away at Banhardih in the district of Latehar. It has coal reserves to meet the requirement of PVUNL for over forty years.

Developing the coal mine to meet the coal requirements of PVUN starting from March 2022 is quite a challenging task for Chakrabarti. Besides the socio-economic issues, he has to deal with environmental issues such as deforestation, land degradation, soil pollution, air pollution, and water intrusion (Kumar et al, 2019).Banhardih is an open cast mine, the operation of which may cause loss of more forest, flora, and fauna. This would be compensated, sector-wise, with heavy afforestation drive post-mining. Before proceeding further Environmental Impact Assessment (EIA) clearance (Exhibit – 5) would be necessary.

At times, coal fire takes place producing toxic gases, subsidence, particulate matters, destruction of floral and faunal habitats, and loss of non-renewal resources. It becomes disastrous if not controlled in time. Mining operations lead to emission of fugitive gases, particulate matters, methane, Sulphur dioxide, and nitrogen oxides. These emissions cause breathing problems in the people residing in nearby areas and global warming for all of us. Goswami (2015) found that

the sulphur in the coal deposits of this region is organic as well as pyretic in nature. The organic Sulphur is structurally bound in coal and is difficult to separate, wash or drain. But pyretic Sulphur is present as an intrusion in the coal seams and the immediate vicinity in the form of balls – circular or elliptical mass or fine, dispersed particles. These tiny particles are responsible for acid mine drainage (AMD) leading to water pollution. Leeching of aquifuge, aquiclude and igneous intrusions and effluent of oil and grease from the machines may lead to pollution of heavy metal such as lead, zinc, arsenic, and cadmium.

All these problems are unavoidable, but with proper planning,Chakrabarti aimed to minimize the impact on the environment and society. The land acquisition process was in progress. In line with NTPC policy, community development work, skill development activities, and many other developmental activities would be taken up in consultation with the district authorities for better livelihood of the affected families. Tree plantation would be taken up on large scale in post-mining areas to restore bio-diversity. Ramagundam project of NTPC is an example where the massive plantation by NTPC led to drop in atmospheric temperature by three degrees Celsiusin peak summer (Reddy, 2000). In order to avoid air pollution, arrangements for dust suppression will be made. To reduce generation and spread of coal dust, conveyor will be used from pit head to the coal washery. A dust mask will be made mandatory for those working in mining areas. There will be a separate budget for environment management. Presence of heavy metals, fluorides, and TDS will be regularly checked and safe drinking water will be provided to the project affected families (MOEF, 2014).Chakrabarti plans to build catch drains and siltation ponds to arrest silt and sediments flow from soil, OB and mineral dumps. The collected water will be recycled for use in dust suppression, and watering of road, green belt, mine area, township. A wildlife conservation plan will be used to protect flora and fauna.

After getting familiar with the environmental issues at different verticals at PVUNL, Chakrabarti felt confident of resolving them one by one. He had a highly competent team of Engineering, Finance, Contract Services, and project execution at the site to take care of issues arising at each step (Exhibit - 6) in the execution of this turn-key project. NTPC had delegated him the powers of a regional executive director so that he could take all decisions related to the new project, old project, and the coal mines. If there is any plant with large scale tree transplantation, ZLD, ACC, FGD, SCR, most modern ultra-supercritical technologyin one place, it is Patratu.

Patratu Super Thermal Power Project is a unique model of project execution where many novel ideas have been either implemented or are in the pipeline. More and more problems will crop up from time to time that Chakrabarti would have to solve. Time alone will tell whether the project has succeeded in evaluation on an iron triangle or diamond model of project management (Exhibit – 7).

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**Exhibit 1: Environment Protection Rule for Emissions from Thermal Power Plants**

| *Condition* | *SPM ($mg/Nm^3$)* | *$SO_2$ ($mg/Nm^3$)* | *NOx ($mg/Nm^3$)* | *Mercury ($mg/Nm^3$)* |
|---|---|---|---|---|
| Installed before December 31, 2003 | 100 | 600* | 600 | 0.03 |
| Installed after December 31, 2003 but before December 31, 2016 | 50 | 600* | 300 | 0.03 |
| Installed after December 31, 2016 | 30 | 100 | 100 | 0.03 |

** For unit capacity of > 500 MW this limit was 200 $mg/Nm^3$*

*(Source: Ministry of Environment, Forest and Climate Change Gazette Notification dated December 7, 2015.)*

**Exhibit 2: Emission of Carbon Dioxide for Different Hydrocarbon Fuels**

| *Type of fuel* | *$CO_2$ (Lb/MBTU)* | *$CO_2$ (Gm/KiloJoule)* |
|---|---|---|
| Coal (Anthracite) | 228.6 | 0.983 |
| Coal (lignite) | 215.4 | 0.926 |
| Coal (subbituminous) | 214.3 | 0.921 |
| Coal (bituminous) | 205.7 | 0.884 |
| Diesel fuel and heating oil | 161.3 | 0.693 |
| Gasoline (without ethanol) | 157.2 | 0.676 |
| Propane | 139 | 0.598 |
| Natural gas | 117 | 0.503 |

*(Source: US Energy Information Administration (2019).How much carbon dioxide is produced when different fuels are burned?; retrieved on 16.06.2019 from https://www.eia.gov/tools/faqs/faq.php?id=73&t=11)*

**Exhibit 3: Sustainable Development Goals for 2030 as Identified in United Nation's GSDR, 2015**

| *Goal* | *Goal description* |
|---|---|
| Goal 1 | "End poverty in all its forms everywhere" |
| Goal 2 | "End hunger, achieve food security and improved nutrition and promote sustainable agriculture" |
| Goal 3 | "Ensure healthy lives and promote well-being for all at all ages" |
| Goal 4 | "Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all" |
| Goal 5 | "Achieve gender equality and empower all women and girls" |
| Goal 6 | "Ensure availability and sustainable management of water and sanitation for all" |
| Goal 7 | "Ensure access to affordable, reliable, sustainable and modern energy for all" |
| Goal 8 | "Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all" |
| Goal 9 | "Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation" |
| Goal 10 | "Reduce inequality within and among countries" |
| Goal 11 | "Make cities and human settlements inclusive, safe, resilient and sustainable" |
| Goal 12 | "Ensure sustainable consumption and production patterns" |
| Goal 13 | "Take urgent action to combat climate change and its impacts" |
| Goal 14 | "Conserve and sustainably use the oceans, seas and marine resources for sustainable development" |
| Goal 15 | "Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss" |

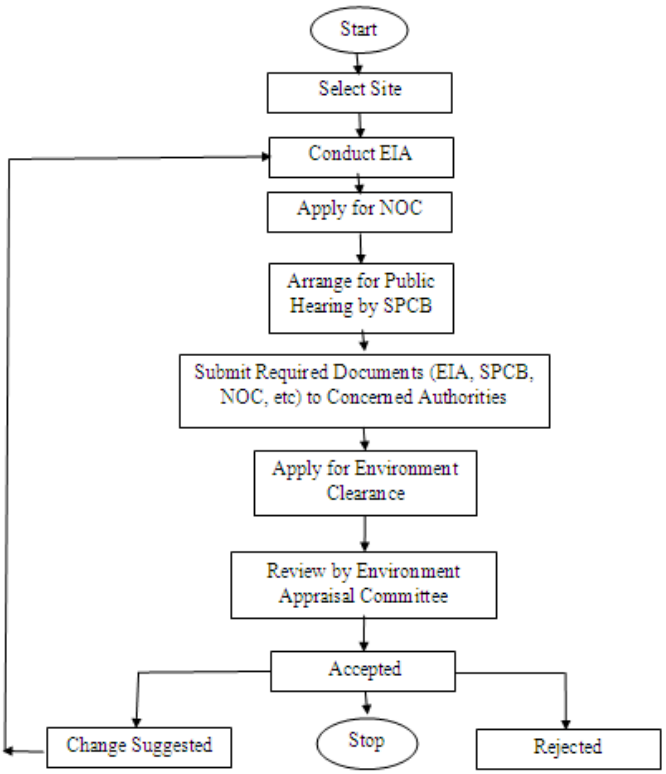
| *Goal* | *Goal description* |
|---|---|
| Goal 16 | "Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels" |
| Goal 17 | "Strengthen the means of implementation and revitalize the global partnership for sustainable development" |

*(Adapted from "Transforming Our World: The 2030 agenda for Sustainable development")*

**Exhibit 4: Tree Transplantation Machine**


*Source: YouTube*

**Exhibit – 5: Environment Impact Assessment (EIA) Clearance Flow Chart**



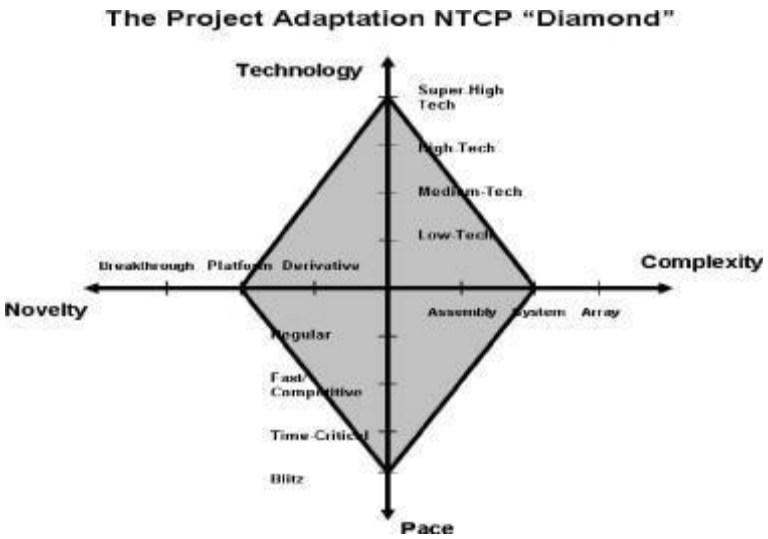

*(Source: Centre for Science and Environment. Retrieved (June 25, 2017) fromhttps: //www.google.co.in/imgres?imgurl=http://www.cseindia.org/userfiles/chart(1).jpg)*

**Exhibit 6: Project Development Process in a Thermal Power Plant**

| *Phase* | *Activity* |
|---|---|
| *Conception and feasibility studies* | Define the need for the development |
| | Evaluate plant capacity |
| | Analyze technology |
| | Evaluate site(s) |
| | Environment impact assessment |
| | Obtain permits and regulatory approvals |
| | Prioritize project objectives |
| | Analyze project tasks |
| | Prepare conceptual scopes and estimates |
| | Prepare preliminary design options |
| | Define project implementation approach |
| | Establish project control approaches |
| *Project planning* | Plan and develop project requirements |
| | Process requirements and prepare design brief |
| | Prepare conceptual design and specification |
| | Prepare bid documents and Request For Proposal (RFP) |
| | Establish prequalification evaluation criteria |
| *Bidding and contracting* | Conduct prequalification exercise |
| | Shortlist pre-qualified contractors for tender |
| | Contractors submit bids and proposals |
| | Evaluate bids |
| | Negotiate contracts |
| | Appoint contractors |
| *Project implementation* | Administer contract |
| | Contractors develop detailed design |
| | Review design and give approvals |
| | Approve subvendors and subcontractors |
| | Contractors proceed with construction and commissioning |
| | Control quality on site |
| | Commissioning |

*Source: Chaudhary, 2014; Project Management Information Systems for Construction of Thermal Power Plant: A Case Study with Special Reference to NTPC Limited, India.*

**Exhibit 7: NTCP Diamond Model**




*Source: Mehta, 2016; Application of Diamond Approach of Project Management*