सत्यमेव जयते

Norms for Manpower Requirement in Thermal Power Sector

Government of India
Ministry of Power
Central Electricity Authority

December, 2022

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The Committee constituted by the HRD Division, CEA vide order No. 13/2/2022-HRD/971 dated 04/08/2022, consisted of the following:

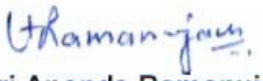
Shri Praveen Gupta
Member (Thermal), CEA
Chairman of the Committee

Shri J N Prasad
Chief Engineer (TPM), CEA
Member Convener

Smt. Seema Saxena
Chief Engineer (HRD), CEA
Member

Shri Vijay Chand
GM (BE), NTPC Limited
Member

Shri M Raghu Ram
Member (Tech), DVC Limited
Member



Shri Ananda Ramanujam K
GM (O&M), NLCIL
Member

Representative
Ministry of Power
Member

The Committee presents its report for consideration of the Ministry of Power.

New Delhi
December 2022

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1.0 Executive Summary

Manpower in thermal sector varies from one project to another owing to the variations in the number of project components, the geographical spread of projects, and geology of the locations wherein the components are to be deployed. Further, a host of other factors such as inaccessible site locations, hostile weather conditions and resistance from the local community etc. play a major role in deciding the requirement of manpower. It has also been observed that manpower requirements vary substantially, even for similar projects located in the same geographical locations.

Data of manpower deployed in some *Central Public Sector Undertakings (CPSUs)* have been sought and analyzed with some state / private sector organizations. It has been observed that, there is a large variation in manpower deployed in CPSUs and state / private organizations. Owing to this, the norms for allocation of manpower in thermal power projects are framed considering the requirement of manpower to cater various activities/ works involved in the projects.

Manpower requirement also varies in different phases of the project such as *Survey & Investigation*, *Under Construction* and *Operation*. Per MW manpower requirement decreases with increase in installed capacity (MW) of the project. Considering this, multiplication factors (Manpower/ MW) for various Installed Capacities (viz. 210 MW, 250 MW, 500 MW 660 MW, 800 MW and their multiples or combinations) have been worked out in the report. To accommodate various complexities involved in a thermal power project including combined cycle gas power plants (viz. expanse, no. of units, no. of components, accessibility, socio-environmental factors, inhabitability, geography etc.), different complexity factors varying from 1.0 to 1.2 for different stages of project i.e. *Survey & Investigation*, *Under Construction* and *Operation* have been worked out in the report. Manpower requirement of a project is determined as product of size (installed capacity), *Multiplication Factor* and *Complexity Factor* of the project.

Further, it is stated that in this report (man/MW) contractual/ outsourced manpower is also included, however, these contractual/outsourced people are employed in the offices of the project developer (for example NTPC) only to provide non-technical services such as drivers, clerical staff, *safai karamchari* etc. These contractual/ outsourced people are not the part of contractor/bidder (for example BHEL) who have been awarded the project. For under construction plant, the manpower requirement (regular employees)

varies as per the different stages (starting to full swing) of the project and its ratio may be around 1: 9 and the levels of contractual manpower (of bidder/EPC contractor) seen in modern thermal power plants during the construction phase may be as high as 20 times of the regular manpower owing to this attribute.

Similarly, in regard to O&M stage of the power plant, the levels of contractual manpower (of annual contracts for operation and maintenance) seen in modern thermal power plants during the O&M phase may be around 4-5 times of the regular manpower.

The Committee thanks and appreciates the sincere efforts made by officials of MoP, CEA, NTPC, DVC, NLC, SJVNL and other organizations involved in preparation of the report.

2.0 Background

2.1 Constitution of the Committee

A committee has been constituted vide HRD Division, CEA letter no. 13/2/2022-HRD/971 dated 04-08-2022 to standardize the manpower norms to optimize the manpower in thermal sector which will be applicable to all power utilities in thermal power sector, with the following composition:

1. Member (Thermal), CEA – Chairman of the Committee
2. Chief Engineer (TPM), CEA – Member Convener of the Committee
3. Chief Engineer (HRD), CEA – Member
4. Representative from MoP – Member
5. Representative from NTPC - Member
6. Representative from DVC -Member
7. Representative from NLC - Member

Thereafter, nominations were sought from MoP, NTPC,DVC & NLC and final composition of the committee is as under:

1. Sh. Praveen Gupta, Member (Thermal), CEA – Chairman of the Committee
2. Sh. J.N. Prasad, CE (TPM), CEA–Member Convener of the Committee
3. Smt. Seema Saxena, CE (HRD), CEA – Member
4. Representative from MoP – Member
5. Sh. Vijay Chand, GM (BE), NTPC Ltd. – Member
6. Sh. M. Raghu Ram, Member (Tech), DVC Ltd. – Member
7. Sh. Ananda Ramanujam. K, GM (O&M), TPS - I Exp., NLCIL – Member

2.2 Deliberations of the committee

The first meeting of the committee was held on 14.09.2022 (MoM issued on 22.09.2022) wherein a detailed deliberation on manpower requirement were made. It was requested

from the members from NTPC, DVC and NLC to give their input/ data on manpower requirement preferably package wise i.e. main plant / ESP, CHP, AHP, Fire Fighting system, CWP, CT, DM Plant, Compressed Air system, Water treatment plant, Fuel pump house, Chlorination Plant etc. It was agreed that after the receipt of input/data from NTPC, DVC and NLC, a draft report on rationalization of manpower in thermal sector would be prepared and discussed in the subsequent meeting.

2nd meeting of the committee was held on 26.10.2022 (MoM issued on 07.11.2022), to discuss the 1st draft report on manpower norms. It was further requested to review the draft report considering the points raised during 2nd meeting of the committee. Accordingly, 2nd draft report was prepared and circulated to all members of the committee on 26-11-2022.

3rd meeting of the committee was held on 30-11-2022 (MoM issued on 08-12-2022), to discuss/ finalize the revised draft report of the committee. Considering the points raised during 3rd meeting of the committee, it was requested to review the draft report and amend it accordingly.

Pre final draft report was circulated to all committee members for final comments/suggestions on 15-12-2022. The comments/suggestions of members of committee were received and suitably incorporated in the final report and manpower norms are explained in detail in subsequent sections. The final report was issued in January, 2023.

3.0 Power Sector Scenario and Various Stages of Thermal Projects

Power is the most fundamental and most critical driver of the economic growth of any nation. The existence and development of adequate power infrastructure, is essential for sustained growth of any national economy. Indian power sector is one of the most diversified power sector in the world. Power generation sources range from conventional sources such as coal, lignite, natural gas, oil, hydro and nuclear power to non-conventional sources such as wind, solar and agricultural & domestic waste. Electricity demand in the country has increased very rapidly and further expected to increase in the coming years. In order to meet this increasing demand of electricity, massive addition to the generation capacity in the country is required.

India's overall installed capacity, as on 30.11.2022 is 4,09,161.21 MW of which the contribution of fossil-based power is 2,36,018.91 MW, which is about 57.68% of total installed capacity. The share of renewables, hydro and nuclear put together is 1,73,142.30 MW, which is about 42.32 % of total Installed capacity. Coal/Lignite based thermal power projects have an installed capacity of 2,10,605.50 MW (51.47%) followed by gas-based thermal power plants with an installed capacity of 24,824.21 MW (6.07%). Thus, it is likely that the sector-wise manpower requirement norms will be dominated by those determined using coal/lignite based thermal power projects.

	Thermal					Nuclear	Hydro	RES	Grand total
Sector	Coal	Lignite	Gas	Diesel	Total				
State	66737.50	1150.00	7012.05	280.31	75179.86	0.00	27254.45	2483.46	104917.78
Private	73198.00	1830.00	10574.24	308.89	85911.14	0.00	3931.00	115396.36	205238.50
Central	64050.00	3640.00	7237.91	0.00	74927.91	6780.00	15664.72	1632.30	99004.93
Total	203985.50	6620.00	24824.21	589.20	236018.91	6780.00	46850.17	119512.13	409161.21
% of Grand Total	49.85%	1.62%	6.07%	0.14%	57.68%	1.66%	11.45%	29.21%	100.00%

Table 1 : All India Installed Capacity of Power Stations as on 30.11.2022

Thermal power particularly coal based power plants are currently the workhorse of the Indian power sector. Thermal power projects are not only a reliable source of power, but they also add a large installed capacity per unit deployed. Thermal power can be made available at any time as per the demand. It requires less time in construction than a hydropower plant and can be installed at any place irrespective of the existence of fuel.

However, thermal power plants operate on fossil fuels and thus are a major source of air pollution. The gases released contribute to global warming and the fly ash interferes with the flora and the fauna. On the operational side, thermal power plants have a higher maintenance and operational cost, and also a huge requirement of water.

The thermal power sector in the Indian power landscape is unique in nature but replete with several challenges. The large number of project components, geographical spread of the project which includes its distance from the mines or ports, access to start-up power, access to water and the geology of the locations wherein the project is to be deployed, vary considerably from one project to another project. Further, a host of other factors such as resistance from local community, delay in getting clearances, vendor issues, remote site locations, hostile weather, technical and financial issues etc. plays key role in deciding the requirement of manpower. It has also been observed that manpower requirement may vary substantially, depending on the type of technology (subcritical or supercritical), the capacity of the thermal power project and the number of units installed, due to the marginal productivity of labor and the economies of scale. Owing to such external factors, it may be quite difficult to prescribe sector wide norms of manpower requirement for thermal power projects.Nonetheless, in a generic sense, such norms have been developed and are contained in this report. However, the latter must be read in the context of India, where generation was historically dominated by public sector enterprises. These enterprises didn't always had the best manpower requirement norms, since they served the dual purpose of not only profiteering, but also social welfare. Nevertheless, even PSEs have been streamlining their labor force since liberalization and are going neck to neck with international standards. This is largely due to a combined effort of increase in the level of technology, automation, labor productivity, outsourcing, better infrastructure and benchmarking.

The various aspects of the landscape of Indian thermal power sub sector are elaborated upon detail here under project stage wise.

3.1 Survey & Investigation (S&I) Projects:

3.1.1 **Local Community Support**: S&I Projects have unique challenges depending upon the social conditions prevailing in the area. Resistance from the local community itself poses several problems for project development and sometimes requires deployment of senior level officers to liaison with administrative authorities.

3.1.2 **Infrastructure Requirement:** Further, during initial stages of S&I projects, several challenges arise on account of **lack of infrastructure**. Lack of basic amenities may necessitate deployment of more manpower (on rotational basis).

3.1.3 **Environment Conditions**: Sometimes the **environmental conditions** are next to inhabitable. Projects may be located in extremely tough climate e.g. extreme temperatures and high humidity. Projects located in such areas require more manpower.

3.2 Under Construction Projects:

3.2.1 **Spread of the Projects**: A project may have several components spread over long distances. This is specifically true for projects having long conveyor coal feeding system, ash slurry transportation, dry ash handling system, ash dyke water recirculation system and MGR (Merry Go Round) system. Projects with greater spread may require more manpower.

3.2.2 **Design features of the Project**: Type of power plant technology, nos. of units etc. affect the manpower requirements. Further, the number of BoP (Balance of Plant) packages will also decide the manpower requirement. For instance, in projects with a closed cycle cooling arrangement, the number of packages

increases, this demands more manpower. Contrary to this in case of ACC (Air Cooled Condenser) the number of BoP packages decreases, requiring lesser number of manpower. Also, projects situated in coastal areas (open cycle cooling system, readily available crushed imported coal) require less manpower.

3.2.3 **Topographical Conditions**: In situations wherein projects are located in bad geography and in event the locations are remote, the manpower requirement shall increase.

3.2.4 **Infrastructure Requirements:** Roads, bridges, colonies, buildings and land acquisition, rehabilitation & resettlement etc. need a lot of manpower.

3.2.5 **Socio Environmental Factors** are very critical such as response of the local communities towards the project activities. It has been observed that certain communities do detest any industrial developmental activity in their vicinity. In such regions, life-threatening situations emerge, wherein project developers are compelled to suspend site activities when situation becomes adverse.

3.2.6 As the construction activities progress, there is a high likelihood of encountering unforeseen site conditions such as water ingress, rock cover, geothermal conditions, emission of harmful gases and so on, exposure to these conditions may cause health hazards and manpower may have to be deployed on rotational basis (resulting more manpower deployment)

3.3 Plants under Operation & Maintenance (O&M):

3.3.1 **Spread of the Power Plant:** Certain Projects have very unique layouts spread over several kilometers. This is specifically true for projects with coal conveyor

pipe wherein the distance between coal unloading point and power plant can be several kilometers. Further, in some plants ash dyke are located 4-5 kilometers away from the plant. Such projects irrespective of their installed capacity will command more manpower.

3.3.2 Allied infrastructure: Power plants may not be looked upon as 'Power plants and paraphernalia components' in isolation but must be considered in conjunction with other infrastructure which may be necessary for the dwelling/sustenance of employees and their families**.** For the functioning of various amenities as may be necessary for the living/sustenance of all, more manpower is required.

3.4 General Scenario

The fact that a threshold manpower required irrespective of the project capacity has been duly accounted for in this study. The study also accounts for the fact that beyond a certain limit (subject to overall ceiling) manpower requirement stabilizes irrespective of increase in project capacity. For instance, with the passage of time and with the level of automation in the overall working, requirement of some cadres (stenographer for instance) has reduced. While also considering such dynamics, innovative recruitment methodologies such as that on fixed tenure basis are also being resorted to, by the various CPSEs. Further it is also worthy of notice that manpower structure undergoes major changes when employees escalate in cadre by virtue of promotions wherein workmen might shift to supervisory and supervisory might reach to mid-level management by the time of their superannuation. These nuances contribute to the complexity of the dynamism.

4.0 Manpower Norms

In view of the aforesaid considerations, and as also stated earlier, it is not feasible to arrive at standard norms for requirement of manpower for Thermal Power Projects. However, some norms in a generic sense have been developed, subject to the condition, that manpower may be re appropriated from time to time as per the requirements of various phases of theprojects and further subject to a certain degree of flexibility to the developer to upsize/downsize manpower depending upon site conditions.

It is an important consideration that manpower deployed by any Thermal Power Developing agency typically constitutes of three tiers i.e. Executives, Supervisors and Workmen. The Executive cadre includes qualified graduate or post graduate engineers and in the non- technical side management graduates/post graduate in finance, human resources, and qualified chartered accountants and qualified company secretaries. The cadre at initial levels is responsible for the execution of key works, at middle and senior levels are responsible for strategizing for organisational growth and driving the organisation's vision, respectively. Supervisory cadre entails junior officers and junior engineers who are mostly diploma holders or Intermediate CA and so on. The workmen cadre includes mainly ITI technicians, stenographers, office assistants etc.

Manpower Norms for Thermal Projects in Various Stages (i.e. S&I, Under Construction and O&M) are as follows:

4.1 For S&I Projects

For S&I projects manpower requirement shall be a function of *Project Capacity*, *Multiplication Factor (MF)* and *Complexity Factor (CF)*.

Manpower requirement = Project Capacity (MW) x Multiplication Factor (MF) x Complexity Factor (CF)

Multiplication Factor (MF) for S&I Projects

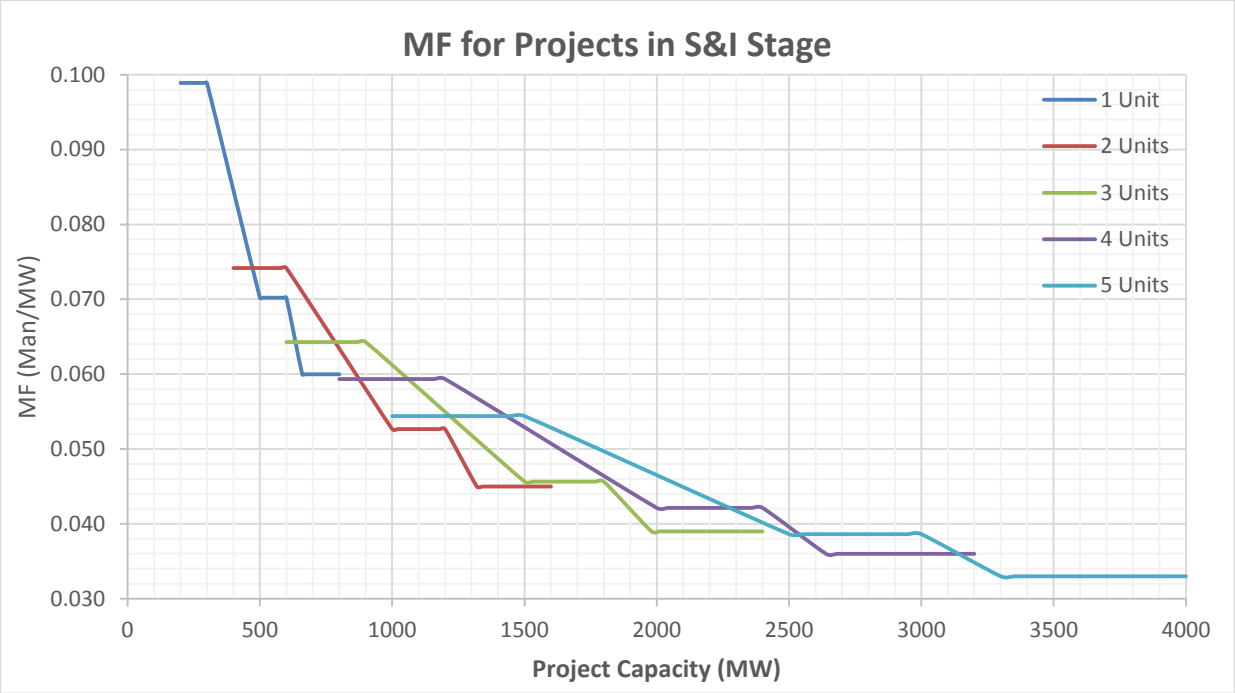
The *Multiplication Factor* has been derived from regression between the project capacities and minimum manpower requirements (Annexure-I). The *Multiplication Factor (MF)* for S&I thermal projects may be read from table as follows:

Table-A

Multiplication Factor Table for Projects in S&I Stage (Man/MW)					
Unit Size (MW)	1 Unit	2 Units	3 Units	4 Units	5 Units
200 – 300	0.099	0.074	0.064	0.059	0.054
500 - 600	0.070	0.053	0.046	0.042	0.039
660 - 800	0.060	0.045	0.039	0.036	0.033

The graphical representation of above table is as under**:**

Fig A



Complexity Factor (CF) for S&I Projects

Since in S&I projects, a host of other factors come into play apart from capacity, the effect of manpower on these factors has been factored in the form of a *Complexity Factor (CF)* which is based on numerous parameters of complexity as encapsulated in the *Complexity Matrix*.

Some of the parameters of *Complexity Factor (CF)* are:

i. **Size of the Project**
ii. **Accessibility (from nearest motorable road)**
iii. **Expanse (Ash dyke location, Coal Receipt point, Water intake point)**
iv. **Geography (Vegetation, sub-soil, rocks)**
v. **Environmental Impact Assessment (EIA) / Clearances**
vi. **Climatic Conditions**
vii. **Resistance from local community**

viii. Accommodation

These parameters have been graded in terms of level of severity on a three point scale: *High*, *Moderate* and *Low*. High severity on any parameter would translate into enhanced manpower requirement. In order to quantify the impact of the parameters on manpower requirement a scoring mechanism has been ascribed which shall generate the overall *Complexity Factor (CF)* for a given project. Use of *Complexity Matrix* is illustrated in Annexure-III.

Complexity Matrix for S&I Projects

Table-B

S. No	Parameter	High	Moderate	Low
1	**Size of the Project**	> 5000 MW	5000 MW - 2000 MW	< 2000 MW
2	**Accessibility (from nearest motorable road)**	Inaccessible (roads need to be constructed)	Moderately accessible (temporary/kuchcha roads available)	Highly accessible (motorable roads available)
3	**Expanse (Ash dyke location, Coal Receipt point, Water intake point)**	More than 5 km	3 km to 5 km	Less than 3 km
4	**Geography (Vegetation, sub-soil, rocks)**	Dense vegetation, hard rocks, no access to river water	Dense vegetation, hard rocks but access to river water	Sparse vegetation, soft rocks and access to river water
5	**Environmental Impact Assessment (EIA) / Clearances**	Difficult to conduct EIA and get clearances	Moderately difficult to conduct EIA and get clearances	EIA easily conducted and clearances readily given
6	**Climatic Conditions**	Extreme Heat (Over 40 degree)/Extreme Cold (zero and subzero temp) For more than 3 months in a year	Moderate Heat (30-40 degree)/moderate cold (0-10 degree) for more than 3 months in a year	Conducive climate (10-30 degree)
7	**Resistance from local community**	Adverse Work Environment, local community response is negative	Average Work Environment, local community response is neutral	Supportive Work Environment, local community response is positive

8	**Accommodation**	Dwelling facility/(Pvt. rented accommodation / Govt. Guest House / Panchayat /Ghar etc) available beyond 8 Km range. Immediate infrastructure requirement To be done in 2-3 months	Dwelling facility (Pvt rented accommodation / Govt. Guest House/Panchayat /Ghar etc) available within over 5- 8 Km range. Infrastructure requirement not immediate but required in over 3-6 months	Dwelling facility (Pvt. rented accommodation/ Govt. Guest House/Panchayat /Ghar etc) available within 5 Km range. Infrastructure requirement not immediate but required in over 6-8 months

The scoring for the matrix (S&I Project) shall be as follows:

Table-C

S.No	Parameter	High	Moderate	Low
1	Size of the Project	0.10	0.09	0.08
2	Accessibility (from nearest motorable road)	0.20	0.18	0.17
3	Expanse (Ash dyke location, Coal Receipt point, Water intake point)	0.25	0.23	0.21
4	Geography (Vegetation, sub-soil, rocks)	0.15	0.14	0.13
5	Environmental Impact Assessment (EIA) / Clearances	0.18	0.17	0.15
6	Climatic Conditions	0.12	0.11	0.10
7	Resistance from local community	0.10	0.09	0.08
8	Accommodation	0.10	0.09	0.08
	Total	**1.20**	**1.10**	**1.00**

The scoring for the matrix shall be the sum of individual scores

It is noteworthy that for low complexity projects the *Complexity Factor (CF)* shall be 1.0 and in case of S&I projects for high complexity, the same may go up to 1.2. Further, a flexibility to the tune of 5%-10% shall be vested with the developing agency in consideration of unforeseen circumstances, though the likelihood of such events is low in thermal power projects.

4.2 For Construction Projects

On analogy similar to the case of S&I Projects**,** for construction projects, manpower requirement shall be a function of *Project Capacity*, *Multiplication Factor (MF)* and *Complexity Factor (CF)*.

Manpower requirement = Project Capacity (MW) x Multiplication Factor (MF) x Complexity Factor (CF)

Multiplication Factor (MF) for Construction Projects

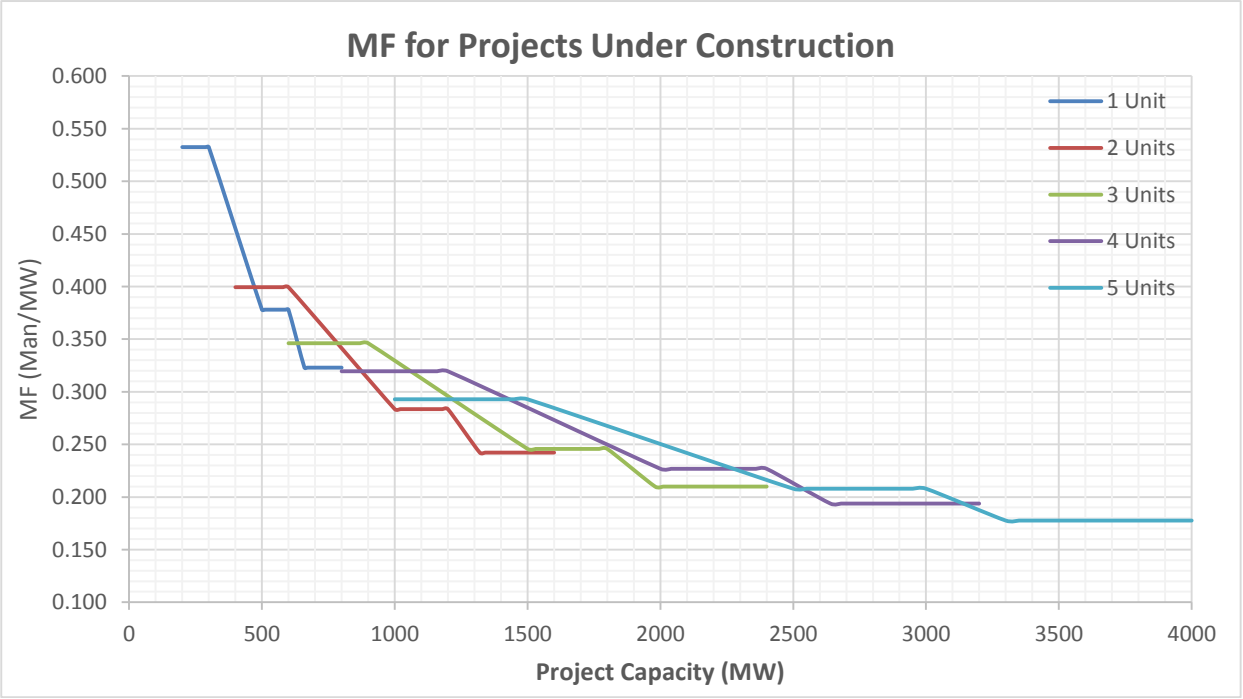
The *Multiplication factor* has been derived from regression between the project capacities and minimum manpower requirements. The *Multiplication Factor (MF)* for under construction thermal projects may be read from table as under:

Table-D

Multiplication Factor Table for Projects Under Construction Stage (Man/MW)					
Unit Size (MW)	1 Unit	2 Units	3 Units	4 Units	5 Units
200 – 300	0.533	0.399	0.346	0.320	0.293
500 - 600	0.378	0.284	0.246	0.227	0.208
660 - 800	0.323	0.242	0.210	0.194	0.178

The graphical representation of above table is as under**:**

Fig-B



Complexity Factor (CF) for Construction Projects

While *Multiplication Factor (MF)* has been generated by simple regression analysis of manpower requirements on the basis of project capacities, it is pertinent to mention that construction projects entail extremely **complex situations** of which the **size of the project** is only one measure. There are a myriad of factors such as **number of packages, startup power availability, water access etc.** that can be **attributed to 'project complexity'**. Similarly, sometimes projects of large capacities do not pose many challenges as their layout is simpler and site & topographical conditions are sound. However, sometimes projects of moderate capacities may entail difficult topographies and elaborate layouts. Thus, as in case of S&I projects, an attempt has been made to **quantify the level of complexity** in respect of construction projects by introducing *Complexity Factor* for construction projects. The same can be understood from the *Complexity Matrix* for construction projects contained in subsequent portions. Use of Complexity Matrix is illustrated in Annexure-III.

Some of the parameters of *Complexity Factor (CF)* are:

i. **Size of the Project**
ii. **Ease of Outsourcing**
iii. **Accessibility (Rail/Road Link)**
iv. **Expanse (Ash dyke location, Coal Receipt point, Water intake point)**
v. **Climatic Conditions**
vi. **Number of additional packages**
vii. **Type of Combustion Technology**
viii. **Seismic Zone**
ix. **Resistance from local community**
x. **Remaining Land Acquisition**

These parameters have been graded in terms of level of severity on a three point scale: *High*, *Moderate* and *Low*. High severity on any parameter would translate into enhanced manpower requirement. In order to quantify the impact of the parameters on manpower requirement a scoring mechanism has been ascribed which shall generate the overall *Complexity Factor* (CF) for a given project.

Complexity Matrix for Construction Projects:

Table-E

S. No	Parameter	High	Moderate	Low
1	**Size of the Project**	> 5000 MW	5000 MW - 2000 MW	< 2000 MW
2	**Ease of Outsourcing**	Lightly outsourced	Moderately outsourced	Heavily outsourced
3	**Accessibility (Rail/Road Link)**	Difficult access both by rail and road	Easily accessible either by rail or road	Easily accessible by rail and road
4	**Expanse (Ash dyke location, Coal Receipt point, Water intake point)**	More than 5 km	3 km to 5 km	Less than 3 km
5	**Climatic Conditions**	Extreme Heat (Over 40 degree)/Extreme Cold (zero and subzero temp) for more than 3 months in a year	Moderate Heat (30-40 degree)/moderate cold (0-10 degree) for more than 3 months in a year	Conducive climate 10-30 degree
6	**Number of additional packages**	De-NO_x ready, FGD ready, Water cooled condenser, Standard Packages**	Water cooled condenser, Standard Packages**	Air cooled condenser, Standard Packages**
7	**Type of Combustion Technology**	Supercritical (800 MW, 660 MW)	Subcritical (500/600 MW)	Subcritical (250 MW, 210 MW and less)
8	**Seismic Zone**	Zone IV and V	Zone II and III	Zone I
9	**Resistance from local community**	Adverse Work Environment, local community response is negative	Average Work Environment, local community response is neutral	Supportive Work Environment, local community response is positive
10	**Remaining Land Acquisition**	Difficult	Moderately Difficult	Easy

Note: ** List of standard BoP packages to be considered:

1. Chimney
2. Coal Handling Plant
3. Ash Handling Plant
4. Ash Dyke water recirculation
5. Fuel Oil System
6. Cooling Towers
7. CW Pump House

8. Compressed Air System Fire Protection System
9. Water Pre Treatment (WPT) Plant
10. DM Water Plant
11. DM Water Transfer Pump House
12. Mill Reject System
13. Plant Service Water system
14. Chlorination plant/ Hydrogen plant
15. Effluent Treatment Plant
16. CPU / COLTCS
17. Switch Yard

The scoring (CF) for the Matrix (under construction Project) shall be as follows:

Table-F

S.No.	Parameter	High	Moderate	Low
1	Size of the Project	0.10	0.09	0.08
2	Ease of outsourcing	0.15	0.14	0.13
3	Accessibility (Rail/Road Link)	0.15	0.14	0.13
4	Expanse (Ash dyke location, Coal Receipt point, Water intake point)	0.20	0.18	0.17
5	Climatic Conditions	0.12	0.11	0.10
6	Number of additional packages	0.13	0.12	0.11
7	Type of Combustion Technology	0.11	0.10	0.09
8	Seismic Zone	0.10	0.09	0.08
9	Resistance from local community	0.10	0.09	0.08
10	Remaining Land Acquisition	0.04	0.04	0.03
Total Score		**1.20**	**1.10**	**1.00**

The scoring for the Matrix shall be the sum of Individual scores

It is noteworthy that for low complexity projects the *Complexity Factor* (CF) shall be 1.0 and in case of under construction projects of high complexity, the same may go up to 1.2. In addition to the manpower as above, a flexibility to the tune of 5%-10% shall be vested with the developing agency in consideration of unforeseen circumstances.

4.3 For Plants under O&M

Manpower requirement = Project Capacity (MW) x Multiplication Factor (MF) x Complexity Factor (CF)

On analogy similar to the case of S&I and construction projects, for O&M projects, manpower requirement shall be a function of *Project Capacity*, *Multiplication Factor (MF)* and *Complexity Factor (CF)*.

Multiplication Factor (MF) for O&M Projects

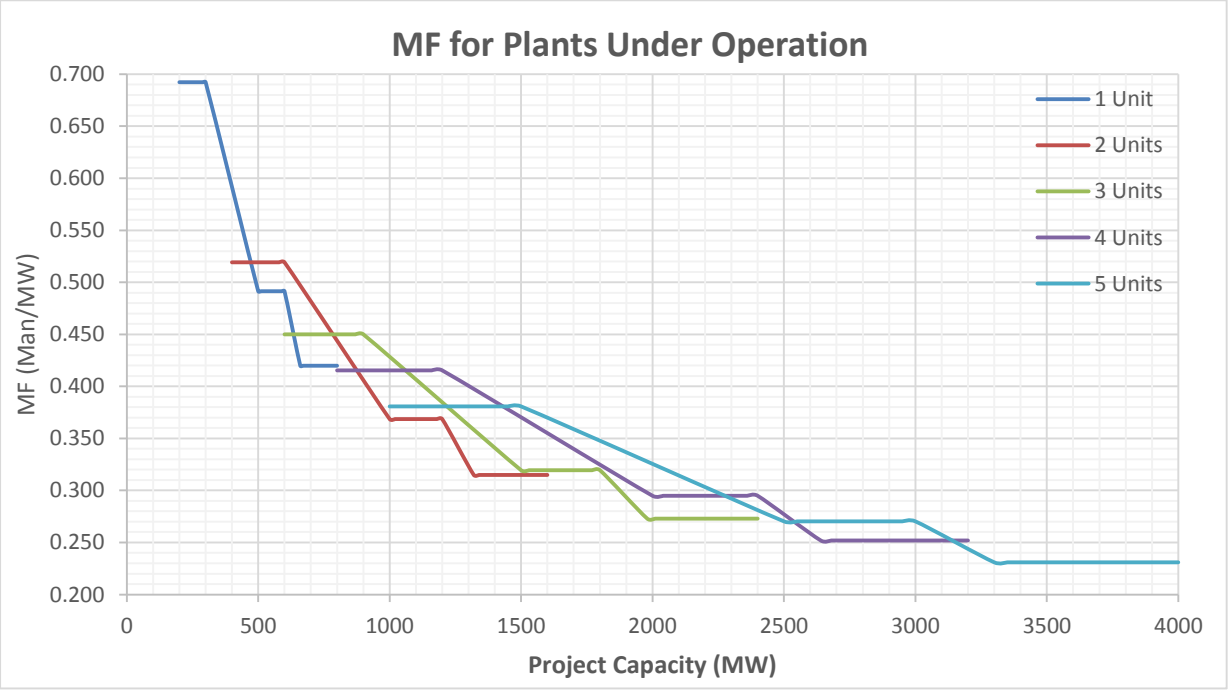
The *Multiplication Factor* has been derived from regression between the project capacities and minimum manpower requirements. The *Multiplication Factor (MF)* for operational thermal power plants may be read from the table as under:

Table-G

Multiplication Factor Table for Plants Under Operation (Man/MW)					
Unit Size (MW)	1 Unit	2 Units	3 Units	4 Units	5 Units
200 – 300	0.692	0.519	0.450	0.415	0.381
500 - 600	0.491	0.369	0.319	0.295	0.270
660 - 800	0.420	0.315	0.273	0.252	0.231

The graphical representation of above table is as under**:**

Fig-C



Complexity Factor (CF) for O&M Plants:

While Multiplication Factor has been generated by simple regression analysis of manpower requirements on the basis of project capacities, it is pertinent to mention that manpower of power plants under O&M is also contingent upon a host of other factors such as size of the project, expanse of the project (ash dyke location, coal receipt point, water intake point), type of combustion technology, transmission line under control, number of townships/colonies etc.. The same can be understood from the *Complexity Matrix* and scoring thereof for power plants under O&M is contained in subsequent portions.

Some of the parameters of *Complexity Factor (CF)* are:

i. **Size of the Project**
ii. **Distance from Coal Mines/Ports**
iii. **Expanse (Ash dyke location, Coal Receipt point, Water intake point)**
iv. **Ash management and utilization**
v. **Ash dyke operation**
vi. **Ease of Outsourcing**
vii. **Water Management and Optimization**
viii. **Flue Gas Desulphurization Plant**
ix. **Safety and Disaster Management**
x. **Quality of fuel (indigenous/imported coal)**
xi. **Type of Combustion Technology**
xii. **Climatic Conditions**

These parameters have been graded in terms of level of severity on a three point scale: *High*, *Moderate* and *Low*. High severity on any parameter would translate into enhanced manpower requirement. In order to quantify the impact of the parameters on manpower requirement a scoring mechanism has been ascribed which shall generate the overall *Complexity Factor (CF)* for a given project. Use of *Complexity Matrix* is illustrated in Annexure-III.

Complexity Matrix for Projects under O&M:

Table-H

S. No	Parameter	High	Moderate	Low
1	**Size of the Project**	> 5000 MW	5000 MW -	< 2000 MW

			2000 MW	
2	**Distance from Coal Mines / Ports**	More than 500 km	500 km -100 km	Less than 100 km
3	**Expanse (Ash Dyke Location, Coal Receipt Point, Water Intake Point)**	More than 5 km	3 km to 5 km	Less than 3 km
4	**Ash Management and Utilization**	Ash management is difficult	Ash management is moderately easy	Ash management is easy
5	**Ash Dyke Operation**	more than 5 Km from power plant	within 5 - 3 km from power plant	up to 3 km from power plant
6	**Ease of Outsourcing**	Lightly Outsourced	Moderately Outsourced	Heavily outsourced
7	**Water Management and Optimization** (Complexity to be considered high if desalination plant is needed due to coastal project)	Water and effluent management is difficult	Water and effluent management is moderately easy	Water and effluent management is easy
8	**Flue Gas desulphurization plant : a) Distance of limestone source from plant b) Distance of gypsum market from plant**	More than 500 km	500 km -100 km	Less than 100 km
9	**Safety and Disaster Management a) Flood Management b) Cyclone Management**	Seismic Zone IV and V	Seismic Zone II and III	Seismic Zone I
10	**Quality of fuel (Indigenous/Imported Coal)**	Blended (10 %)	Blended (more than 10%)	100% imported
11	**Type of Combustion Technology**	Supercritical (800 MW, 660 MW)	Subcritical (500/600 MW)	Subcritical (250 MW, 210 MW and less)
12	**Climatic Conditions**	Extreme Heat (Over 40 degree)/Extreme Cold (zero and subzero temp) For more than 3 months in a year	Moderate Heat (30-40 degree)/moderate cold (0-10 degree) for more than 3 months in a year	Conducive climate 10-30 degree

The scoring for the Matrix (O&M Projects) shall be as follows:

Table-I

S No.	Parameter	High	Moderate	Low
1	Size of the Project	0.08	0.07	0.06
2	Distance from coal Mines/Ports	0.10	0.09	0.08
3	Expanse (Ash Dyke Location, Coal Receipt Point, Water Intake Point)	0.14	0.13	0.12
4	Ash Management and Utilization	0.13	0.12	0.11
5	Ash Dyke Operation	0.11	0.10	0.09
6	Ease of Outsourcing	0.12	0.11	0.10
7	Water Management and Optimization (Complexity to be considered high if desalination plant is needed due to coastal project)	0.12	0.11	0.10
8	Flue Gas desulphurization plant : a) Distance of limestone source from plant b) Distance of gypsum market from plant	0.10	0.09	0.08
9	Safety and Disaster Management	0.09	0.08	0.08
10	Quality of Fuel (Indigenous/Imported Coal)	0.08	0.07	0.07
11	Type of Combustion Technology	0.07	0.07	0.06
12	Climatic Conditions	0.06	0.06	0.05
Total		**1.20**	**1.10**	**1.00**

The scoring for the Matrix shall be the sum of Individual scores

It is noteworthy that for low complexity projects the Complexity Factor shall be 1.0 and in case of under O&M plants of high complexity, the same may go up to 1.2. In addition to the manpower as above a flexibility to the tune of 5%-10% shall be vested with the developing agency in consideration of unforeseen circumstances.

4.4 Other Key considerations :

i. Manpower in any thermal power developing agency typically constitutes three tiers: the executives, the supervisors and the workmen. The executive cadre includes qualified graduate or post graduate engineers and in the non-technical side management graduates in finance, human resources, and qualified chartered accountants and qualified company secretaries. The cadre at initial levels is responsible for the execution of key works and at middle and senior levels are responsible for strategizing the organisational growth and driving the organisation's vision respectively. Supervisory cadre entails junior officers and junior engineers who are mostly diploma holders or Intermediate CA and so on. Further, the workmen cadre includes mainly ITI technicians, stenographers, office assistants and the likes.

ii. The norms have been proposed for executives, supervisors and workmen (regular and non-technical contractual) at any stage of development of project (i.e. S&I, under construction and O&M)**.** It is also pertinent to point out the difficulty in establishing norms that includes the technical contractual manpower (Annexure-II).

iii. These Norms are also applicable to Lignite based thermal power projects.

iv. The ratio of executives to supervisors is ideally in range of 70:30 for S&I and under construction projects. Further, the ratio of executives to supervisors is ideally in the range of 50:50 for plants under O&M. *However, this may vary from one organisation to the other. For example, this can be as high as 80:20 (as suggested by NTPC) to as low as 50:50 (as suggested by DVC, NLC). The project authorities have the autonomy to decide their own manpower structures.*

v. The ratio of executives to non-executives (includes supervisors and workmen) is ideally 40:60 for S&I and construction projects. Further, the ratio of executives to non-executives (includes supervisors and workmen) is ideally 20:80 for projects under operation. *However, this may again vary from one organisation to the other.*

For example, this can be as high as 40:60 (as suggested by NTPC, DVC) to as low as 30:70 (as suggested by DVC). The project authorities have the autonomy to decide their own manpower structures.

vi. In supervisors cadre the ratio of regular to contractual employees may ideally be 1:1.

vii. The proportion of technical manpower is 75 % - 80 %.

viii. The non-critical works of the project may be outsourced depending on the availability of regular manpower.

ix. Maintenance of *Balance of Plant* equipment can be carried out on annual maintenance contract basis and the manpower for same will be separate.

x. The total manpower worked out from above formulae may be used to cater all the functions / requirements of the project except security personnel of CISF / state police / government corporations deployed for plant security as well as colonies /townships security, if any.

4.5 Manpower of Corporate/Central Services:

4.5.1 Centralized Services:

Apart from the functions at project sites, there are a host of other activities that are performed in conjunction with project activities but may not necessarily be housed at project sites. Such set of functions that cater to the overall business of the organisation may be referred to as the centralised functions. The same includes (but is not limited to): civil & electrical design, formulation of contracts, geography, environment, cost engineering, project monitoring, planning, O&M, commercial, quality assurance and inspection, salary, wages.

4.5.2 Corporate Functions

There are a set of functions that are performed for the overall working and sustenance of the organisation and as such cannot be seen in direct conjunction with the projects. Such functions include business development, strategy development, planning finance and internal audit, IT & Cyber security, vigilance, company secretary, CSR wing, policy formulation, recruitment, training, manpower planning and so on. Such functions may be referred to as corporate functions.

It is worth to mention that the *Multiplication factor (MF)* for each S&I, under construction and O&M projects includes manpower required for centralised services as well as corporate functions.

The strength to be deployed for the centralized and corporate functions at corporate / regional offices will be the discretion of the corporation as per the functioning of the departments and the prevailing organisational requirements.

5.0 Observations, Limitations and Deviations:

5.1 Results have been found to hold good for projects ranging between 500 MW – 3000 MW (across all stages), however for projects beyond this capacity results may vary. There may also be outliers which won't conform to the model.

5.2 Other project specific factors such as operation of projects in 2 shift / 3 shift may cause the actual manpower requirement to vary from what the current study generates.

5.3 External factors such as projects located in pithead / non pithead (located in same geography) may cause the actual manpower requirement to vary from what the current study generates.

5.4 This study has been generated on the basis of the overall installed capacity of the stage of a thermal power project. This is because the manpower requirement is a much stronger function of the capacity of the individual unit that is to be installed and also the number of units that are going to be installed. There is going to be a lower manpower requirement when more units are installed, since a lot of functions / packages will get shared across these units.

5.5 *The greater the capacity of the individual unit, the lower the manpower requirement (Man/MW).* This is because it usually takes the same manpower to operate a unit of any thermal power plant. So, if the same manpower is used to operate a unit of larger capacity, the manpower requirement per quantum of power generated will fall.

5.6 *The more the number of units of a particular unit size, the lesser the manpower requirement (Man/MW)*. A typical power plant is developed in expansion stages. Each stage is made up of a number of units. Often, the *Balance of Plant* components are common across the units and the stages. Similarly, the manpower that is required to operate these components is shared between the units, thus resulting in a lower manpower requirement.

5.7 *Supercritical units have a lower manpower requirement (Man/MW) when compared to sub-critical units*. As can be seen from the data, the manpower requirement is dependent on the capacity of the individual unit. Thus power projects of about similar capacities have different manpower requirements, depending on the technology (subcritical or supercritical) that is being used. This difference is due to the fact that supercritical units have lesser number of components and more installed capacity when compared to subcritical units.

6.0 Manpower and Machinery required on-Hold/Stalled Thermal Power Projects:

During the construction of any thermal power projects, there is always possibility of occurrence of unforeseen site conditions, which may lead to delay in construction of project and in some cases, project might also get stalled.

Major reasons, which may lead to delay in execution of thermal power projects are:

- Law & Order / R&R Issues
- Contractual Issues / PPA Issues
- Financial Issues, i.e., cash flow constraints with the developer and / or contractor
- Technical Challenges (viz. poor geography, design issues etc.)
- Force Majeure (viz. natural disaster, COVID etc.)

Due to above reasons, the thermal power projects may get stalled until the issues are resolved. Till such time, the deployed manpower of developer may not be required at the site. This will unnecessarily increase the establishment cost of the project leading to higher overall project cost, which in turn increases the tariff of the project.

In such cases, it is suggested that project developer may re-appropriate the deployed manpower at site to the bare minimum requirement. Project developer may shift the additional manpower to other projects under their control.

Considering all facts, the norms for manpower requirement of developer for thermal projects under S&I would be applicable at stalled thermal projects.

Further, issues related to idling of Manpower & Machinery of contractor deployed at stalled project site may be dealt separately as it is a contractual issue.

7.0 Conclusion:

Given the complexities of thermal power development, the merits of the latter, especially the fact that thermal plants can generate power to the grid and can provide reliable power along with its capacity to get pooled with greener forms of energy, weighs over all cons. From the perspective of manpower, it is noteworthy that thermal power sector is perhaps one of the challenging sectors for employment. The project locations are sometimes remote and in many instances not easily accessible. In addition, the dynamics of local community interference pose several challenges that sometimes escalate to life threatening situations. Thus, the thermal power scenario is at large variance from any other source of power such as nuclear or for that matter solar/wind.

However, manpower deployment continues to remain a very critical consideration. It is worthy of appreciation that deployment of right manpower of varied strata at the right locations can save huge costs by curbing time over runs.

Keeping such considerations in mind, *Manpower Norms* have been generated by factoring in the various dynamics of thermal power projects while also vesting in a degree of flexibility to the developers.

8.0 Results Summary: Manpower norms as per the report for various installed capacities of Thermal Power Projects/Plants

For under Survey & Investigation (S&I) Projects (Man/MW)					
Unit Size (MW)	1 Unit	2 Units	3 Units	4 Units	5 Units
200 – 300	0.099	0.074	0.064	0.059	0.054
500 - 600	0.070	0.053	0.046	0.042	0.039
660 - 800	0.060	0.045	0.039	0.036	0.033

Flexibility to the tune of 5% - 10% is vested with the project authority.

For under Construction Power Projects (Man/MW)					
Unit Size (MW)	1 Unit	2 Units	3 Units	4 Units	5 Units
200 – 300	0.533	0.399	0.346	0.320	0.293
500 - 600	0.378	0.284	0.246	0.227	0.208
660 - 800	0.323	0.242	0.210	0.194	0.178

Flexibility to the tune of 5 % - 10 % is vested with the project authority.

For under Operation Power Plants (Man/MW)					
Unit Size (MW)	1 Unit	2 Units	3 Units	4 Units	5 Units
200 – 300	0.692	0.519	0.450	0.415	0.381
500 - 600	0.491	0.369	0.319	0.295	0.270
660 - 800	0.420	0.315	0.273	0.252	0.231

Flexibility to the tune of 5 % - 10 % is vested with the project authority.

***

Annexure-I

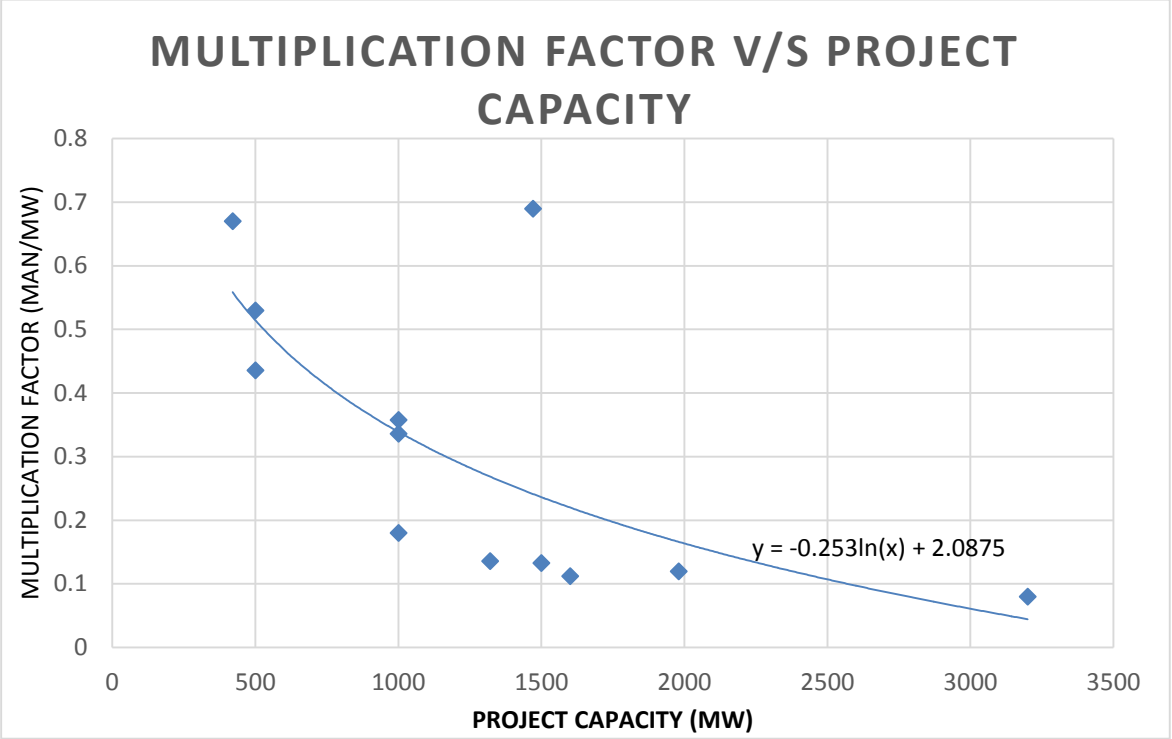
Genesis of Multiplication Factors

The Multiplication Factors have been generated using regression. This was done for standard unit sizes and also for multiple units of similar unit size. In case of a combination of different unit sizes, a weighted average as per the capacities can be taken.

For instance, to calculate the Multiplication factors for the manpower requirement in the power plant operation phase, the data was collected from various project agencies. This data is shown below:

Project Capacity (MW)	Unit Size (MW)	Number of Units	Manpower Requirement (Man/MW)	% of Workforce that is Executive	% of Workforce that is Technical	Remarks
			0.130			International benchmark for coal based operating stations
			0.630		77%	Current Norms - NEP
420	210	2	0.670			NLCIL
500	500	1	0.530	49%	83%	DVC
500	250	2	0.436			NLCIL
1000	500	2	0.358			NLCIL
1000	500	2	0.180			NLCIL
1000	500	2	0.336	49%	85%	DVC
1320	660	2	0.136	82%		NTPC
1470	210	7	0.690			NLCIL
1500	500	3	0.133	84%		NTPC
1600	800	2	0.112	39%		NTPC
1980	660	3	0.120			NLCIL
3200	800	4	0.080	36%		NTPC

Logarithmic regression was implemented using the logarithmic trendline feature of spreadsheets. Logarithmic regression has been used because logarithmic trendline is a best-fit curved line that is most useful when the rate of change in the data increases or decreases quickly and then levels out.



The equation of best fit was obtained as:

Multiplication Factor (Man/MW) **= -0.253 x Natural Log (Unit Size** (MW)**) + 2.0875**

This equation of best fit was then used to calculate the *Multiplication Factors* for standard unit sizes. The results obtained are shown below:

Unit Size (MW)	Man/MW
200 – 300	0.692
500 - 600	0.491
660 - 800	0.420

These value were then factored for different number of units so as to satisfy two conditions, one, that for the same project capacity, more number of units will require more total manpower and two, the requirements of total manpower diminish as project capacity is increased. The final *Multiplication Factor* table is shown as:

Multiplication Factor Table for Plants Under Operation (Man/MW)					
Unit Size (MW)	1 Unit	2 Units	3 Units	4 Units	5 Units
200 – 300	0.692	0.519	0.450	0.415	0.381
500 - 600	0.491	0.369	0.319	0.295	0.270
660 - 800	0.420	0.315	0.273	0.252	0.231

Similar tables were generated for S&I and Under Construction stages by factoring this table and benchmarking from projects/plants.

Annexure-II

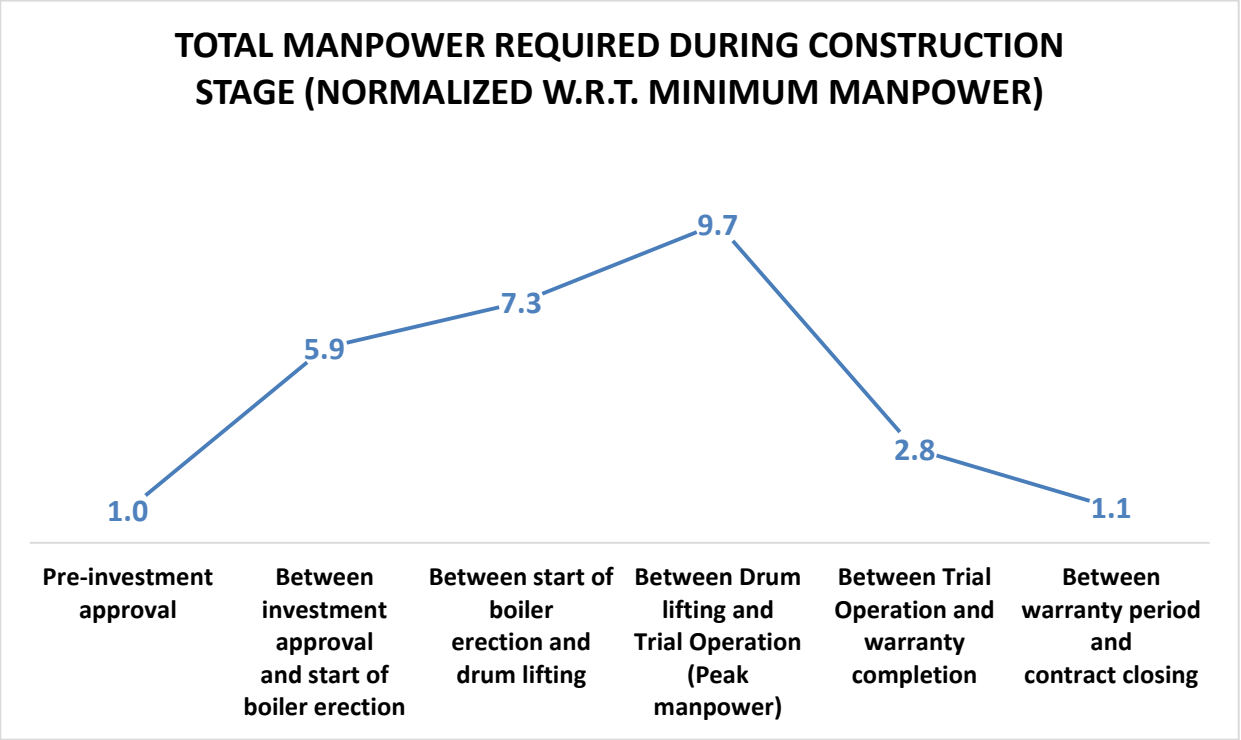
Variability in manpower requirements during the various phases of construction stage

The construction stage of a thermal power plant is the intermediate step in the thermal power plant life cycle. This stage of the project is also the period during which most of the visible activity takes place in terms of men and machineries. The various phases that mark the construction stage are:

- Pre-investment approval
- Start of boiler erection
- Drum lifting
- Trial Operation
- Warranty completion
- Contract closing

The manpower requirement is highly variable during these phases. As per POWER HR FORUM (Published in 2006, March) report, the manpower requirement during the construction stage varied in the following manner:

Stage of Project	Executive	Non-Executive	Total	Total Manpower (Normalized wrt Minimum Manpower)
Pre-investment approval	13	-	13	1.0
Between investment approval and start of boiler erection	62	15	77	5.9
Between start of boiler erection and drum lifting	80	15	95	7.3
Between Drum lifting and Trial Operation (Peak manpower)	92	34	126	9.7
Between Trial Operation and warranty completion	37	-	37	2.8
Between warranty period and contract closing	14	-	14	1.1



As can be seen from the graph of normalized manpower, the peak manpower requirement may be as high as ten times of the minimum manpower. This requirement is typical to any modern thermal power project.

Thus, it also becomes a difficult task to precisely determine the amount of manpower requirement that should be met using contractual workforce. It is seen that contractual manpower may be as much as 20 times of the regular manpower in the construction phase during peak times. The data pertaining to such contractual manpower is often not present with the project authorities, since most of the contracts are awarded on a turnkey basis. However, in a few cases, the contractual manpower involved in non-technical works (clerical, legal, multi-tasking staff, etc.) is included in the total manpower.

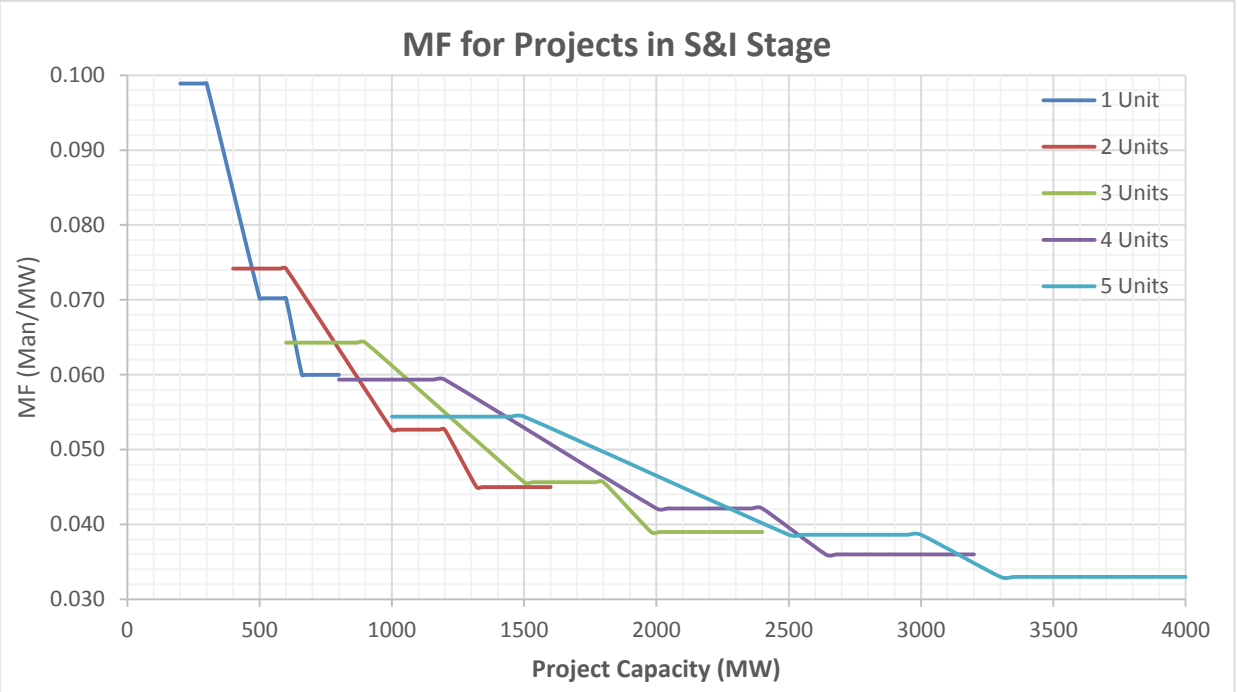
Sample Calculations:

Note: The project specifications are indicative and are considered for sole purpose of understanding the computation methodology.

i. For S&I Project of 660 MW having one unit (1x660 MW) in Jharkhand

Project Specifications: Survey for a Greenfield project is to be done. The project will have a single unit, community support is negative, climate and temperature is conducive to settlement. Accessibility by road or by rail is poor. Expanse of the project is moderate. There is no access to a river but the vegetation is temperate. Accommodation is easily available. Getting EIA done and obtaining clearances is cumbersome.

(1) Multiplication Factor (MF):



Multiplication Factor: as can be ascertained from figure above = **0.060**

(2) Calculation of Complexity Factor

Complexity Matrix

S.No	Parameter	High	Moderate	Low
1	Size of the Project			✓ 0.08
2	Accessibility (from nearest motorable road)	✓ 0.20		

3	Expanse (Ash dyke location, Coal Receipt point, Water intake point)		✓ 0.23	
4	Geography (Vegetation, sub-soil, rocks)		✓ 0.14	
5	Environmental Impact Assessment (EIA) / Clearances	✓ 0.18		
6	Climatic Conditions			✓ 0.10
7	Resistance from local community	✓ 0.10		
8	Accommodation			✓ 0.08
	Total	**1.11**		

Complexity Factor = **1.11**

Calculations

Manpower = Project Capacity x Multiplication Factor x Complexity Factor

⇒ **Manpower = 660 x 0.060 x 1.11 = 44**

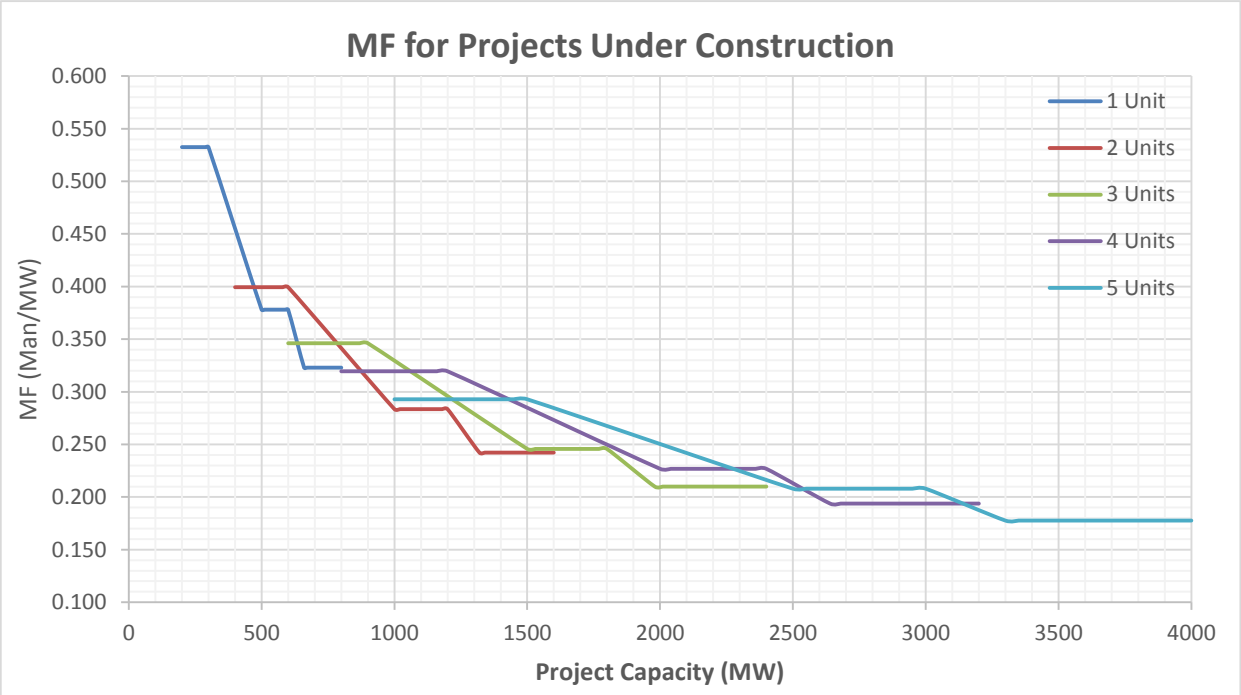
- **Executives (40%* of Manpower) = 18**
- **Non-Executives (60%* of Manpower) = 44 - 18 = 26**
- **Supervisors (70 : 30* :: Executives : Supervisors) = 18 x (30/70) = 8**
- **Workmen = Non-Executives – Supervisors = 26 – 8 = 18**
- **Technical workforce = 80%* of total Manpower (44) = 35**
- **Non-Technical workforce = 20%* of total Manpower (44) = 9**

*The percentages and ratios shown here are indicative. They may be changed as per the project requirement.

ii. For Under Construction Project of 1980 MW having 3 units (3 x 660 MW) in Jharkhand

Project Specifications: Brownfield project, thus good accessibility. The expansion stage will have 3 units, each based on supercritical technology. The expansion stage will have a long expanse. Support from the local community is neutral. Climatic conditions are moderate. The project lies in seismic zone II. Outsourcing is easy due to established vendor relations. The project is FGD ready. However, remaining land acquisition is arduous due to frequent farmer agitations.

(1) Multiplication Factor (MF):



Multiplication Factor: as can be ascertained from figure above **= 0.210**

(2) Calculation of Complexity Factor

Complexity Matrix

S.No.	Parameter	High	Moderate	Low
1	Size of the Project			✓ 0.08
2	Ease of outsourcing			✓ 0.13
3	Accessibility (Rail/Road Link)			✓ 0.13
4	Expanse (Ash dyke location, Coal Receipt point, Water intake point)	✓ 0.20		
5	Climatic Conditions		✓ 0.11	
6	Number of additional packages		✓ 0.12	
7	Type of Combustion Technology	✓ 0.11		

8	Seismic Zone		✓ 0.09	
9	Resistance from local community		✓ 0.09	
10	Remaining Land Acquisition	✓ 0.04		
Total Score		**1.10**		

Complexity Factor = 1.10

Calculations

Manpower = Project Capacity x Multiplication Factor x Complexity Factor

⇒ **Manpower = 1980 x 0.210 x 1.10= 457**

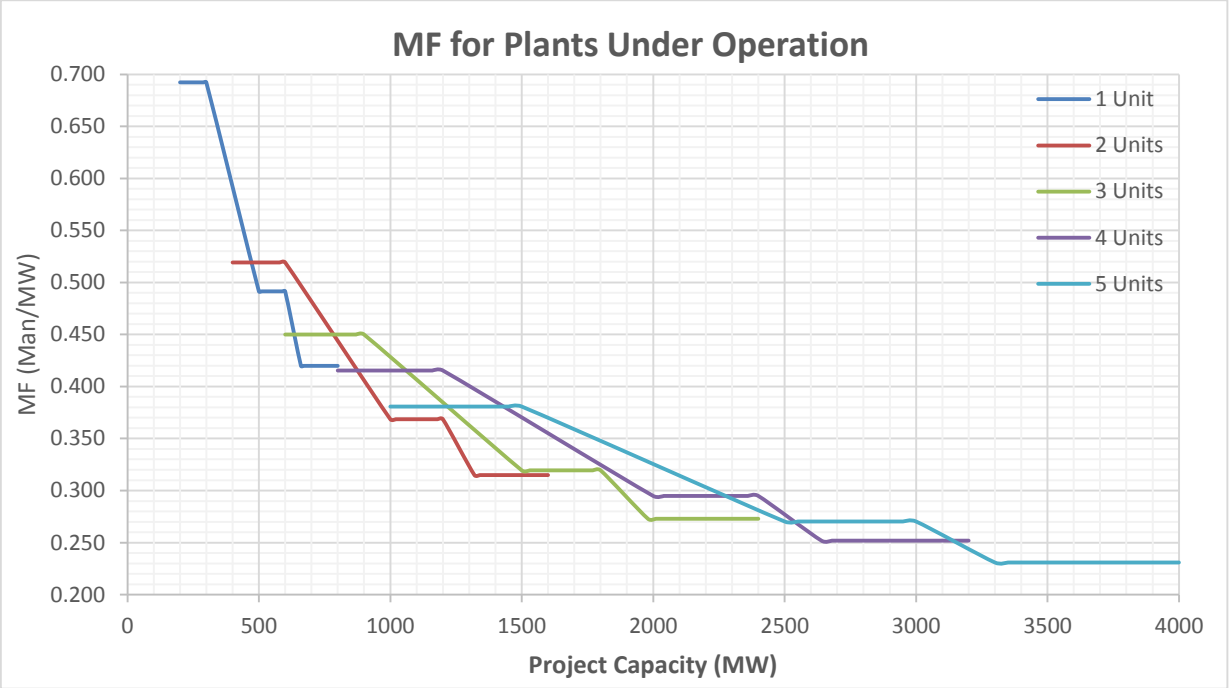
- **Executives (40%* of Manpower) = 183**
- **Non-Executives (60%* of Manpower) = 457-183 = 274**
- **Supervisors (70 : 30* :: Executives : Supervisors) = 183 x (30/70) = 78**
- **Workmen = Non-Executives – Supervisors = 274 – 78 = 196**
- **Technical workforce = 80%* of total Manpower (457) = 366**
- **Non-Technical workforce = 20%* of total Manpower (457) = 91**

*The percentages and ratios shown here are indicative. They may be changed as per the project requirement.

iii. For under O&M Plant of 1000 MW (500 x 2) in Tamil Nadu

Project Specifications: 2 subcritical units of 500 MW each, expanse of the project is within 3 km and it is a coastal project (thus minimizing the distance from ports). Climate is pleasant for most of the year. The project lies is seismic zone I but may be susceptible to tsunamis. Outsourcing is easy. The plant runs entirely on the imported coal. Ash management is difficult due to coastal winds. Desalination plant is needed since it is a coastal project. Ash dyke operation is difficult, since seepage is a major problem. Gypsum and Limestone are readily available.

(1) Multiplication Factor (MF):



Multiplication Factor: as can be ascertained from figure above = **0.369**

(2) Calculation of Complexity Factor

Complexity Matrix

S No.	Parameter	High	Moderate	Low
1	Size of the Project			✓ 0.06
2	Distance from Mines/Ports			✓ 0.08
3	Expanse (Ash Dyke Location, Coal Receipt Point, Water Intake Point)			✓ 0.12
4	Ash Management and Utilization	✓ 0.13		

5	Ash Dyke Operation	✓ 0.11		
6	Ease of Outsourcing			✓ 0.10
7	Water Management and Optimization	✓ 0.12		
8	Flue Gas desulphurization plant : a) Distance of limestone source from plant b) Distance of gypsum market from plant			✓ 0.08
9	Safety and Disaster Management		✓ 0.08	
10	Quality of Fuel (Indigenous/Imported Coal)			✓ 0.07
11	Type of Combustion Technology		✓ 0.07	
12	Climatic Conditions			✓ 0.05
Total		**1.07**		

Complexity Factor = 1.07

Calculations

Manpower = Project Capacity x Multiplication Factor x Complexity Factor

⇒ Manpower = 1000 x 0.369 x 1.07 = 395

- **Executives (20%* of Manpower) = 79**
- **Non-Executives (80%* of Manpower) = 395-79 = 316**
- **Supervisors (1 : 1* :: Executives : Supervisors) = 79 x (1/1) = 79**
- **Workmen = Non-Executives – Supervisors = 316 – 79 = 237**
- **Technical workforce = 80%* of total Manpower (395) = 316**
- **Non-Technical workforce = 20%* of total Manpower (395) = 79**

*The percentages and ratios shown here are indicative. They may be changed as per the project requirement.

End of Report