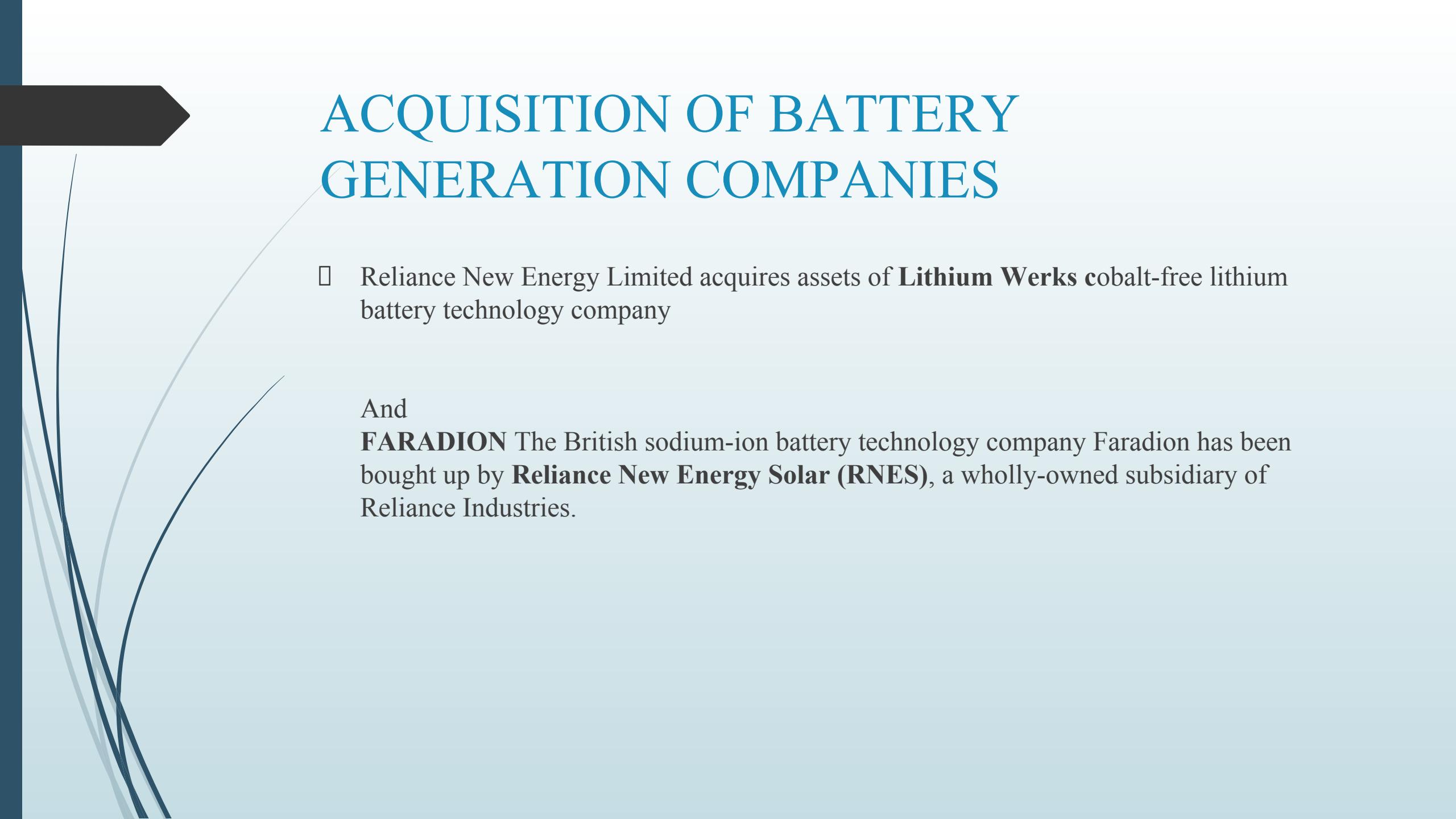




Supply Demand India COAL and other minerals

Dr. Siddhartha Agarwal



ACQUISITION OF BATTERY GENERATION COMPANIES

- Reliance New Energy Limited acquires assets of **Lithium Werks** cobalt-free lithium battery technology company

And

FARADION The British sodium-ion battery technology company Faradion has been bought up by **Reliance New Energy Solar (RNES)**, a wholly-owned subsidiary of Reliance Industries.

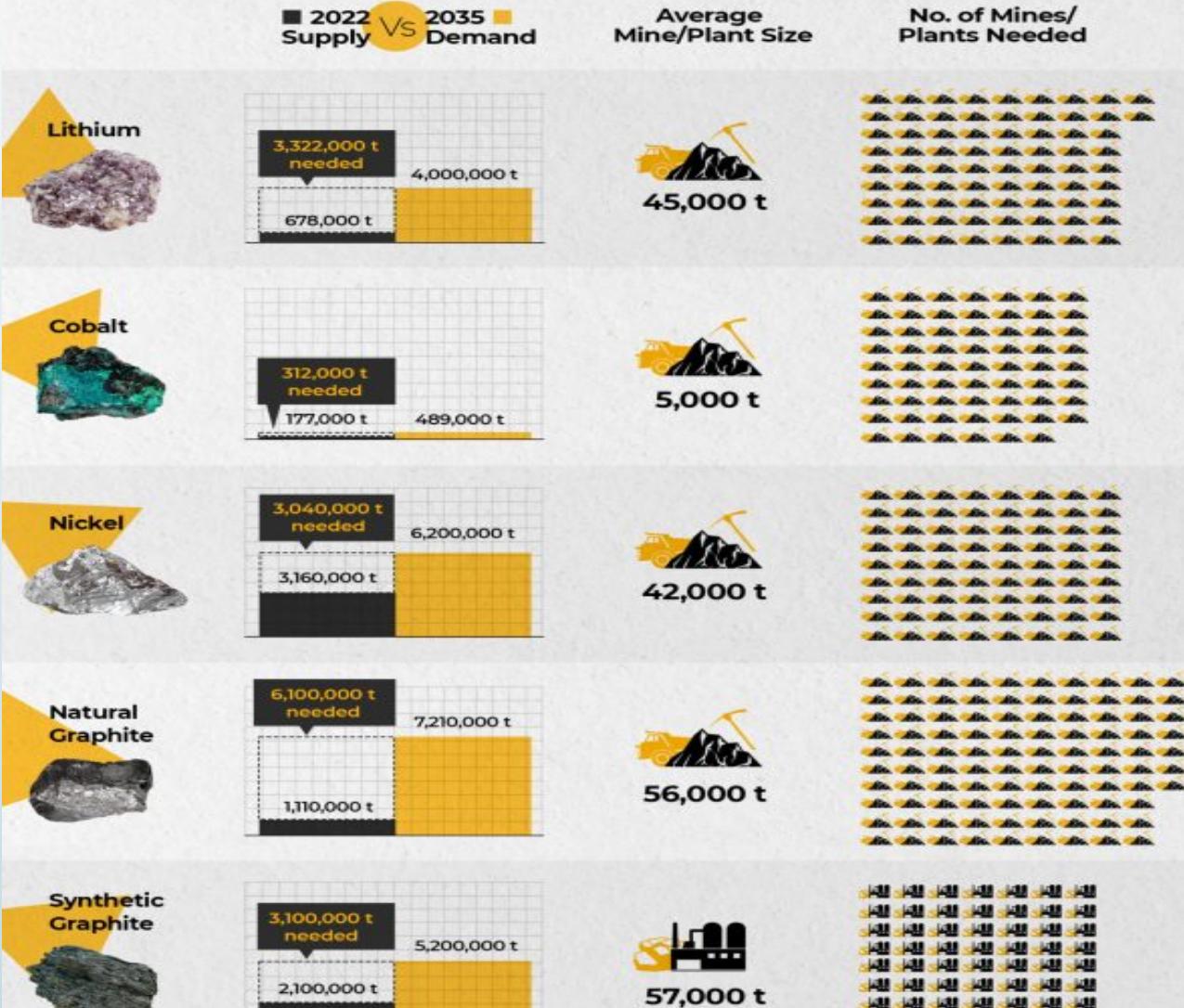


What is difference between lithium-ion and lithium Sulphur battery?

- Li-Ion batteries are reaching their practical specific energy limit. Li-S is one of the most promising technologies to be used in batteries for EV. **Li-S technology has higher theoretical specific energy than Li-Ion.** Li-S is more cheaper and less pollutant than Li-Ion

HOW MANY MINES DO WE NEED?

As the lithium ion battery revolution gains momentum, **Benchmark** forecasts just how many mines need to be built to keep up with the exceptional volumes of demand for key raw materials expected by 2035.



Overall Analysis

1. Analysis from [Benchmark Mineral Intelligence](#)'s raw material forecasts shows at least 384 new mines for graphite, lithium, nickel and cobalt are required to meet demand by 2035, based on average mine sizes in each industry. Taking into account recycling of raw materials, the number is around 336 mines
2. For [#lithium](#), the world will require 74 new lithium mines with an average size of 45,000 tonnes by 2035, or 59 if recycling rates ramp up as expected
3. Issues will also be faced in the midstream, with the need for aggressive expansion of lithium refinery facilities able to produce consistent, battery grade, qualified lithium chemicals being another significant hurdle
4. Looking to [#graphite](#), a total of an estimated 97 natural flake graphite mines will need to be built, assuming an average size of 56,000 tonnes a year, whilst a further 54 synthetic graphite plants with an average size of 57,000 tonnes will also be required
5. How the balance of synthetic vs natural graphite plays out in China compared to the rest of the world will also play a role, but either way a significant volume of raw materials will be required to meet [#anode](#) demand from the [#EV](#) industry

LITHIUM RUSH

1. To meet the world's lithium requirements would require 74 new lithium mines with an average size of 45,000 tonnes by 2035, according to Benchmark. Including forecast volumes from recycled lithium, however, it's around 59 mines.
2. Since mines take at least five years to build these mines will need to be in operation by 2033, according to Cameron Perks, an analyst at Benchmark.
3. "That's around 59 lithium mines up and running in just over 10 years," he said.
4. Australia is set to remain the dominant producer of lithium this decade, according to Benchmark. There are currently over 13 lithium mines producing lithium-containing spodumene rock, over 75% of which is refined in China.

NICKEL AND COBALT

Yet another 72 mining projects with an average size of 42,500 tonnes will be required to meet battery demand for refined nickel, according to Benchmark.

Recycling, however, is set to have the biggest impact on cobalt mining. Without recycling, the world would need to build 62 new cobalt mining projects of 5,000 tonnes each by the end of 2035.

With forecast recycled volumes, however, that number falls by almost half to 38.

COAL CRISIS HITS POWER PLANTS

Even as an unprecedented heat wave sweeps across much of the country and power demand touches an all-time high, thermal plants, the major source of electricity across the country, confront a critical coal shortage

2400 MW Evening peak power shortage



Uttar Pradesh (1,200 MW) and **Haryana** (600 MW) contribute to much of this shortfall.

75%

Percentage of India's electricity supply provided by coal-based thermal power plants.



81/150

Thermal power stations using domestic coking coal where stocks have dropped to the critical level.

Rajasthan and **Uttar Pradesh** have the most number of power plants in critical condition.



25%

Minimum percentage of its mandated coal inventory that a power plant must have; it gets critical below this level,



415 Number of trains, against the requirement of 453, dedicated to transporting coal. The actual number rarely exceeds 400.



The **shortage of railway wagons** ('rakes') allocated for moving coal to power stations is a major reason for the present crisis.

80%

Percentage of coal supplied to different industries that come from the public-sector Coal India Limited.



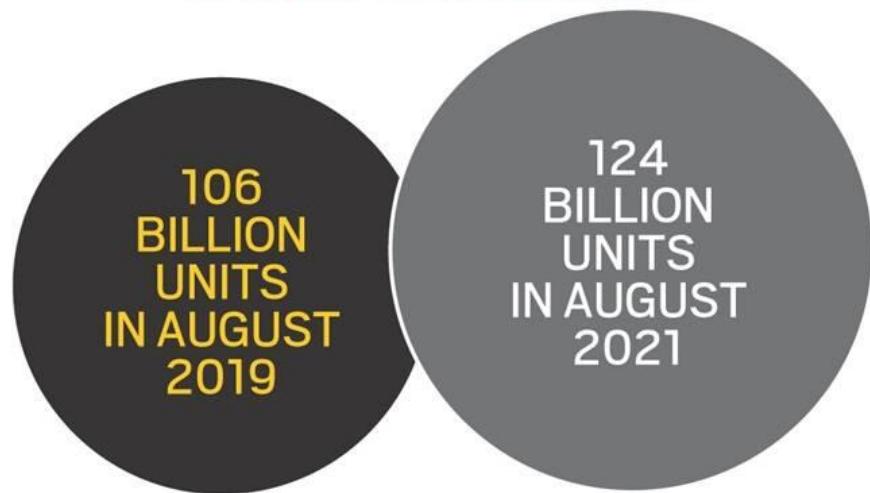
Coal India Limited
A Government of India Undertaking
A Maharatna Company

275K Daily tonnage of coal supplies to aluminum smelters and steel plants slashed by Coal India.

Source: All India Power Engineers Federation (AIPEF)

IANS

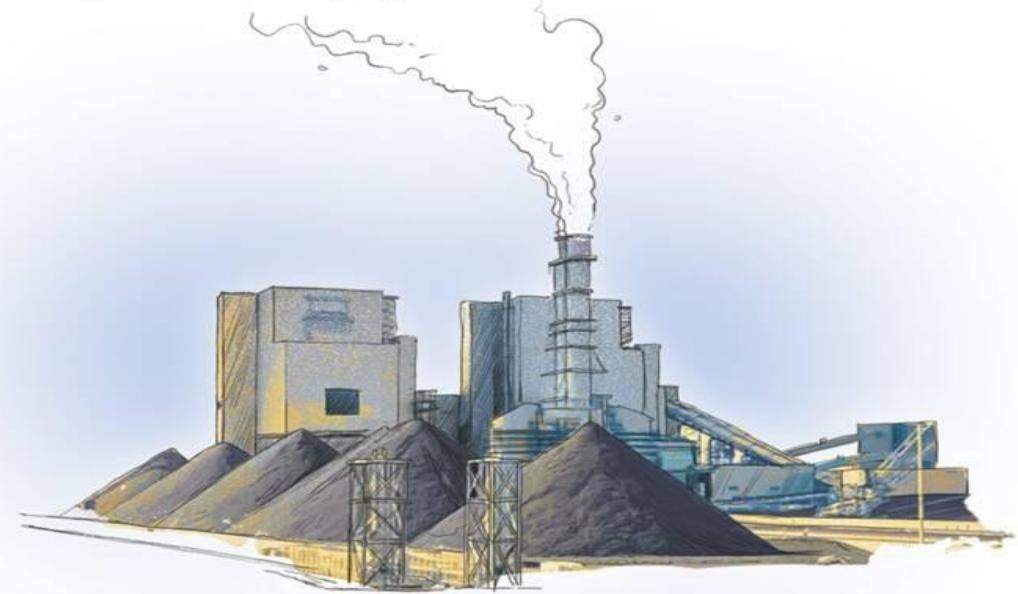
REASONS FOR THE SHORTAGE



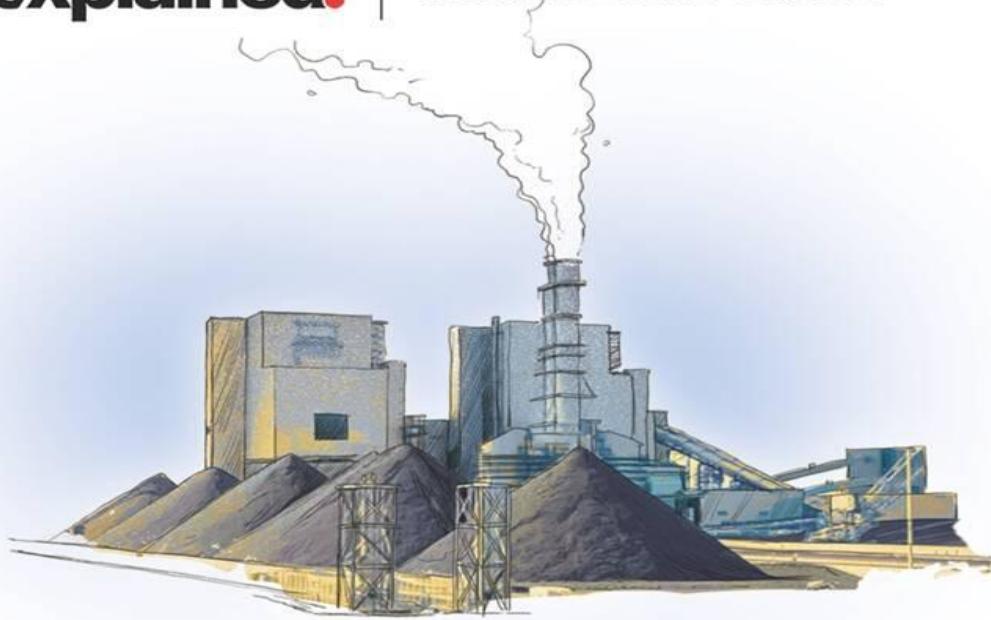
SHARP UPTICK IN DEMAND

- Heavy September rains in coal-mining areas hit production and delivery, and plants failed to build up their stocks pre-monsoon
- Demand had outstripped supply, despite increased buying from Coal India
- Sharp fall in imports due to high prices

INDIA'S COAL CRISIS



- Coal-fired plants make up nearly 70 per cent of India's power source mix
- On October 1, the Power Ministry said that the 135 thermal power plants in the country had only an average of about four days of coal stocks left



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COAL SHORTAGE AND INDIA'S LOOMING POWER CRISIS**WHY IS THERE A COAL SHORTAGE?**

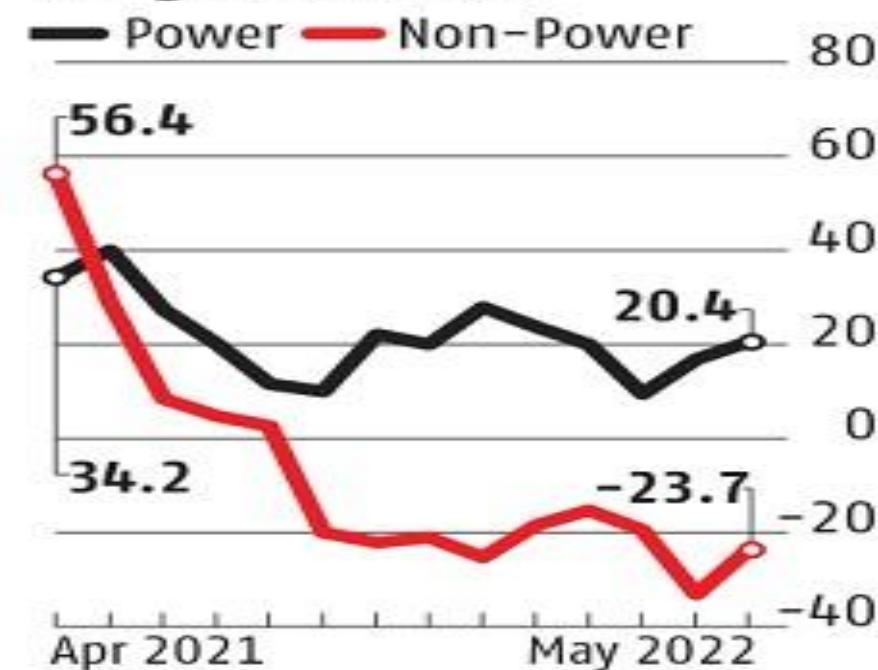
- 108 of 173 thermal power plants have critically low levels of stock
- Power demand is hitting record highs due to economic recovery after COVID-19
- surges and a major heatwave spell across India
- Some imported coal-based power plants are not in production due to high international prices of coal



RUNNING LOW ON SUPPLY



COAL DISPATCH YoY growth (in %)



UNDER PRESSURE

	Apr '21	Apr '22	% change (YoY)		May '21	May '22	% change (YoY)	(In mt)
CIL coal production	41.9	53.5	27.68		42.1	54.7	29.93	
CIL DISPATCH								
Power	42.5	49.7	16.94		43.5	52.4	20.46	
Non-power	11.6	7.8	-32.76		11.5	8.8	-23.48	

Source: Ministry of coal, industry

COAL SUPPLY POSITION

Stock in days (critical/ super critical)	Number of plants	Capacity (Mw)
0 day	6	9,020
1 day	15	17,405
2 days	17	20,602
3 days	10	15,800
4 days	12	16,880
5 days	2	2,770
6 days	6	4,920
7 days	1	540
8 days	0	0
TOTAL	69	87,937



Mode	No. of plants	Capacity (Mw)	Daily req. (in '000 T tonne)	Total stock ('000 T)	Average total stock (in days)
Pithead	16	35,200	434.7	3,412.6	8
Non-pithead	119	133,256	1,475.9	9,964.7	7
TOTAL	135	168,456	1,910.6	13,377.2	7

Mw = Megawatt;

Source: National Power Portal

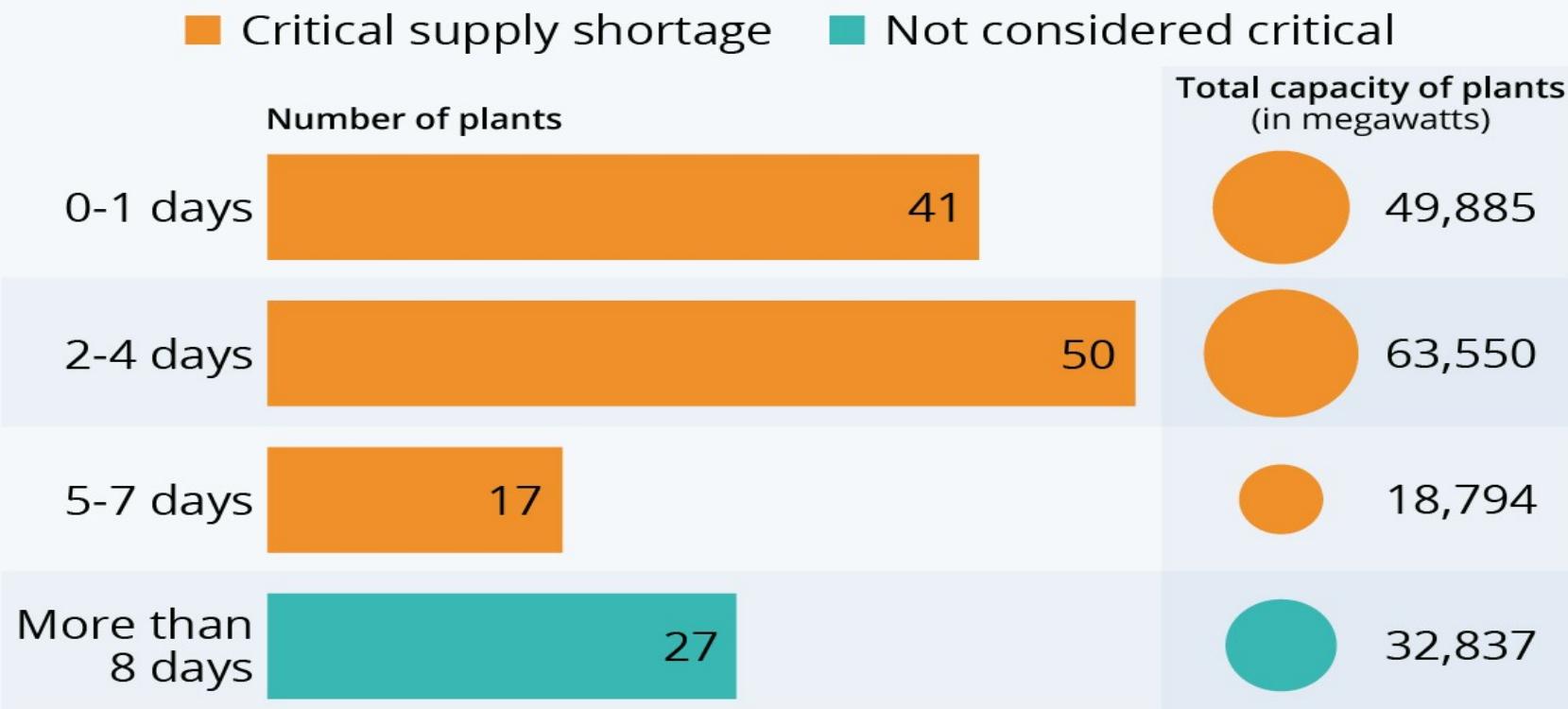
Note: Data is as on 28 August 2021

Non-pithead plants & pithead plants

- **pit-head power plant** means any captive or stand-alone power station having captive transportation system for its exclusive use for transportation of coal from the loading point at the mining end, up to the uploading point at the power station without using the normal public transportation system;
- **Non pit-head power plant** Thermal power plants located away from mines

India Faces Power Outages as Coal Stocks Dwindle

Number of days for which coal reserves exist at Indian power plants registered with the Central Electricity Authority



As of Oct 4, 2021

Source: Ministry of Power Central Electricity Authority

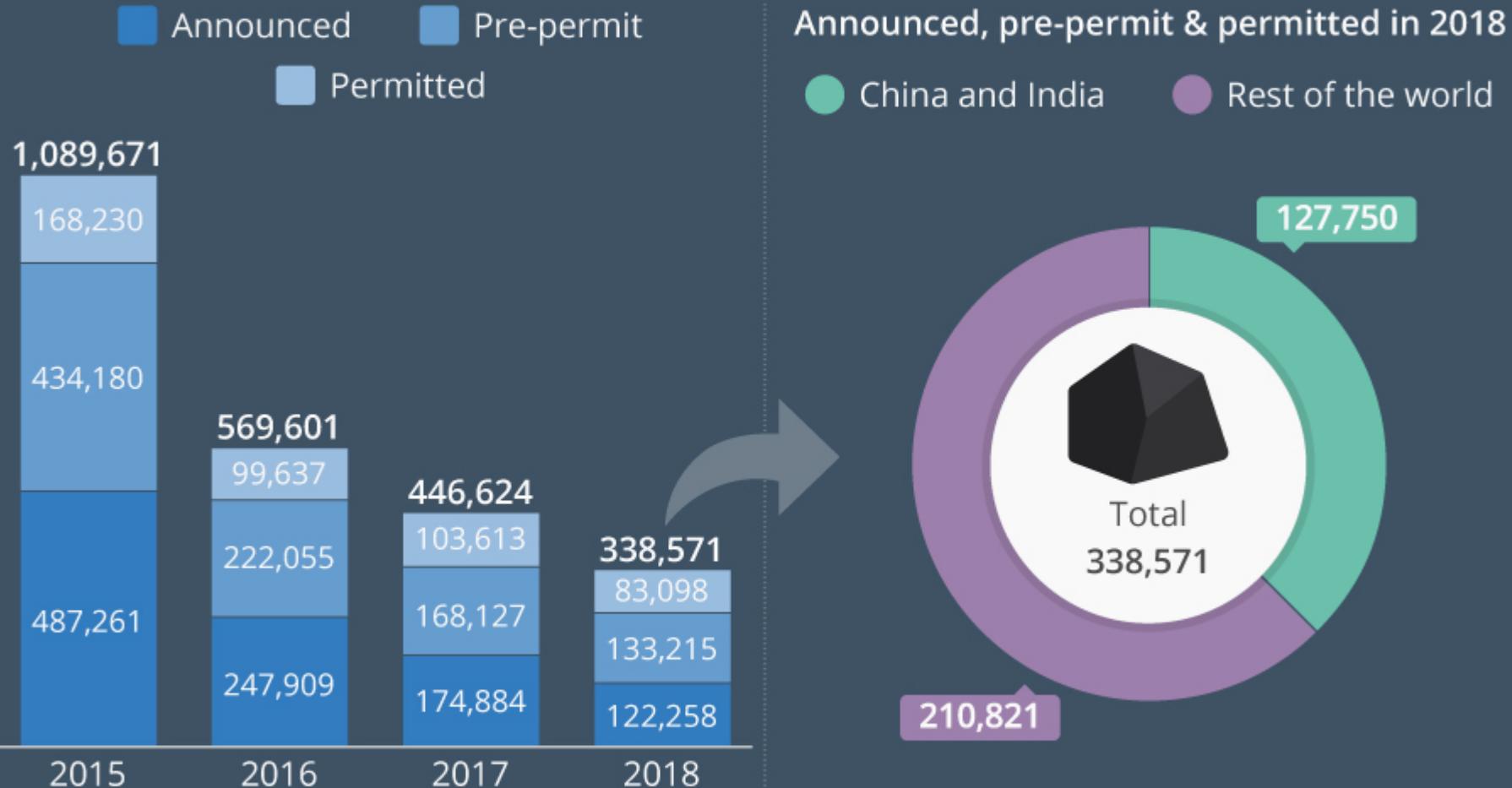
Taking stock

Mode	Pithead	Non-pithead		
	2020	2021	2020	2021
Number of plants	17	16	118	119
Capacity (MW)	34,300	35,200	1,28,226	1,29,866
Daily requirement ('000T)	452.3	464.2	1,327	1,359.9
Total stock ('000T)	5,733.5	2464	28,434.6	5,345.2
Total stock in days	13	5	21	4



New Coal Power Projects Are Declining Globally

Pre-construction coal power capacity in development worldwide (megawatts)



@StatistaCharts

Sources: Global Energy Monitor, Greenpeace India, and the Sierra Club

statista

First Mile Connectivity Projects CIL 2021-22

- Major Advantages of NCL's FMC Projects are
 - Mitigation of Air Pollution,
 - Eliminate Under loading Overloading,
 - Reduction in loading time of rakes from three hours to within one hour,
 - Reduction in rake turn around time ie. load transported/rake/day will increase,
 - Reduction in Road Accident.
- First Mile Connectivity will promote ease of living in coal mine areas by reducing traffic congestion, road accidents and adverse impact on environment**
- CIL is set to invest around Rs 14,200 crore by the year 2023-24, in two phases for its 49 First Mile Connectivity projects**
- Coal PSUs will adopt alternate transport methods like mechanized conveyor systems, computerized loading onto railway rakes etc. replacing road transport in large mines.**
- Of the 14 projects that are coming up under phase II, Central Coalfields Ltd (CCL) will account for five with 62.5 million tonnes per annum capacity. Mahanadi Coalfields Ltd will have a solitary project of 20 million tonnes per annum capacity. Eastern Coalfields Ltd will have seven projects and South Eastern Coalfields Ltd will have one project with a capacity of 14 million tonnes per annum and four million tonnes per annum, respectively.

CIL to undertake digitalization of 7 mines with Accenture to raise coal output 2021-22

1. Accenture would lead and support the implementation of digitalisation and process excellence while assuring 100 MTs increased coal output from the identified mines
2. Learning from the outcome and success of this model we may replicate it in our other large mines, said an official
3. The seven identified mines are **NKusmunda, Gevra, Dipka of South Eastern Coalfields Limited Nigahi, Jayant, DUDHICHUA, Khadia of Northern Coalfields Limited (NCL)**.
4. “The aim is to fit together and use the
 1. available data analytic techniques to raise mine productivity and efficiency from planning,
 2. project monitoring,
 3. operations till despatch
 4. through effective system management and dynamic monitoring.
 5. Among many measures, the HEMM deployed in these mines would be fitted with digital sensors to monitor the efficiency of their performance at every level,” said a press statement issued by CIL.
5. “With the fee linked to the performance, the **consultant assures an increased quantity of 100 MTs coal by end of FY23 over the combined production of seven mines** at the closure of FY22, which is taken as baseline figure to measure output enhancement.
6. Till March 2022, Accenture shall **be laying down the digitalisation groundwork in these mines,”** said Coal India. The coal miner has a target to produce 1 Billion Tonnes (BTs) of coal by 2024.

High yielding mines

1. These high yielding mines accounted for nearly **32 per cent or 188 mt of CIL's total coal output of 596 mt during FY21**. While the three mines of SECL contributed around **112 mt** the remaining (**76 mt**) came through **four of NCL's mines**.
2. “This is a first of its kind initiative by the company utilizing digitalization to ramp up coal output. It will be enabled in seven select mines for transformation across the entire business value chain of mining operations,” a senior company official said in the statement.
3. As per the contract, the consultant’s success fee shall be paid only on achievement of more than a minimum threshold level of the assured quantity. **On crossing the threshold level, the consultant would be paid an agreed sum for every additional tonne of coal produced.**

April 2022, the Indian Railway took many steps to prioritise loading of coal to the power sector which has led to an increase in the supply of coal of more than 10 per cent within one week

1. Railways records **20.4% growth in its coal transportation in FY 2021-22**
2. Compared to 542 million tonnes in 2020-21 fiscal, the railways loaded a **record 653 million tonnes of coal in 2021-22, an increase of 111 million tonnes.**
3. Further, the loading of coal to the power sector was augmented by **32 per cent in just two quarters between September 2021 and March 2022**, the railways said
4. "Movement of coal trains has been prioritised. Each and every train is being intensively **monitored during the entire cycle** from loading to movement and finally unloading
5. With this prioritisation and monitoring, the transit time of trains loaded with coal has been reduced significantly by 12-36 per cent for critical power plants, it said

Transporting Coal: Rs 22,067 Crore Rail Projects Under Implementation In Jharkhand, Odisha And Chhattisgarh

1. Fourteen railway projects are being undertaken towards increasing the efficiency and further enhancing the capacity of the coal evacuation process, which will help **reduce the time and cost incurred in the transportation of the coal.**
2. These projects will cover a distance of 2,680 km and spread across Jharkhand, Odisha and Chhattisgarh. The total estimated cost for these projects is expected to be Rs 22,067 crores.
3. Once these projects are commenced, **they are expected to augment the coal evacuation capacity to 410 Million Tonnes Per Annum (MTPA).**
4. **“Presently, Coal India Limited (CIL) incurs about Rs 3,400 crore on transportation charges of coal. Also, large volumes of coal are transported via road, which many times lead to accidents while passing through rural areas because of narrow and poorly maintained road structures,**
5. To avert these hindrances, the Government has projected to invest in alternative modes of transport, **viz: rail, inland waterways, coastal shipping etc.** These modes aim to **increase the efficiency and effectiveness of the transportation of coal.**

What is Indian railways doing to increase coal transportation

1. Monitoring the entire cycle
2. significant upgrade of track infrastructure near mines that will be focused on coal bearing regions
3. **deploys additional rakes to transport coal to power plants,**
4. Indian Railways **has prioritised the movement of coal to long distance power houses** as well which is reflected in the fact that the average lead of coal trains has increased by 7 per cent

ASK QUESTIONS TO INDUSTRY EXPERTS

1. How is digitalization going to improve the logistics in mines
2. What are current roadblocks in first mile connectivity
3. Problems with modes of coal transport are Rail, Road and the Rail-cum-Sea route and captive modes such as Merry-Go-Round (MGR) Systems, Conveyor Belts and Ropeways. Currently, coal is being transported majorly through railways, followed by road transportation and MGRs.
- 4.

First Mile Connectivity for Energizing India

1. <https://www.youtube.com/watch?v=aCEbgaysnXE>
2. <https://www.facebook.com/mahanadicoal/videos/first-mile-connectivity-for-energising-india/240059964253140/>

- BOX means bogie open high sided, BOXN means **bogie open high sided with air breaks**, BOXN-HA means bogie open high sided with air brakes with higher axel load suitable for 100 kmph speeds, BOXN-CR means bogie open high sided with air brakes with corrosion-resistant steel, BO
- BOBRNWAGONS. (BOGIE OPEN BOTTOM RAPID DISCHARGEHOPPERWAGONS) HISTORY: Bogie Open Bottom Rapid Discharge Hopper Wagon type BOBRwagons are. **developed for movement of bulk quantities of coal from collieries to nearest**. ST means bogie open for finished steel products

Question 5. (20 points) OPTIMAL PRODUCT MIX AND WHAT-IF QUESTIONS

Consider the problem in Question 4: The AU Mines Company own two mines, X and Y, that produce an ore which, after being crushed, is graded into three classes: high, medium and low-grade. The AU Mines have different operating characteristics as detailed below:

Mine	Production (Tons/Day)		
	High	Medium	Low
X	6	3	4
Y	1	1	6

Table-Q5-1. Production output of each mine.

Additional information has become available about the market for the products.

The company has the option the sell the high, medium, low-grade ores extracted from any of the sites to other manufacturers other than the smelting plant. However, the unit revenue (\$/ton) earned from the contract with smelting plant is higher than what the other manufacturers will pay. The revenues are provided below.

Product type	High grade	Medium grade	Low grade
Revenue (\$/ton) when sold to the smelting plant	\$10	\$12	\$8
Revenue (\$/ton) when sold in the market to other manufacturers	\$10	\$9	\$7

Table Q5-2. Revenue per ton from different customers

The demand of the smelting plant must be met exactly because of the contract. The demand for other manufacturers is higher than the company's production capacity. The company has the market power to determine the amount of products to sell to other manufacturers (and can choose to not sell at all). The demand information is provided below.

+	Product type	High grade	Medium grade	Low grade	Demand fulfillment
	Demand of smelting plant	12 tons/week	8 tons/week	24 tons/week	Must be met exactly
	Demand from other manufacturers	unlimited	unlimited	unlimited	Optional

Table Q5-3. Demand from different customers