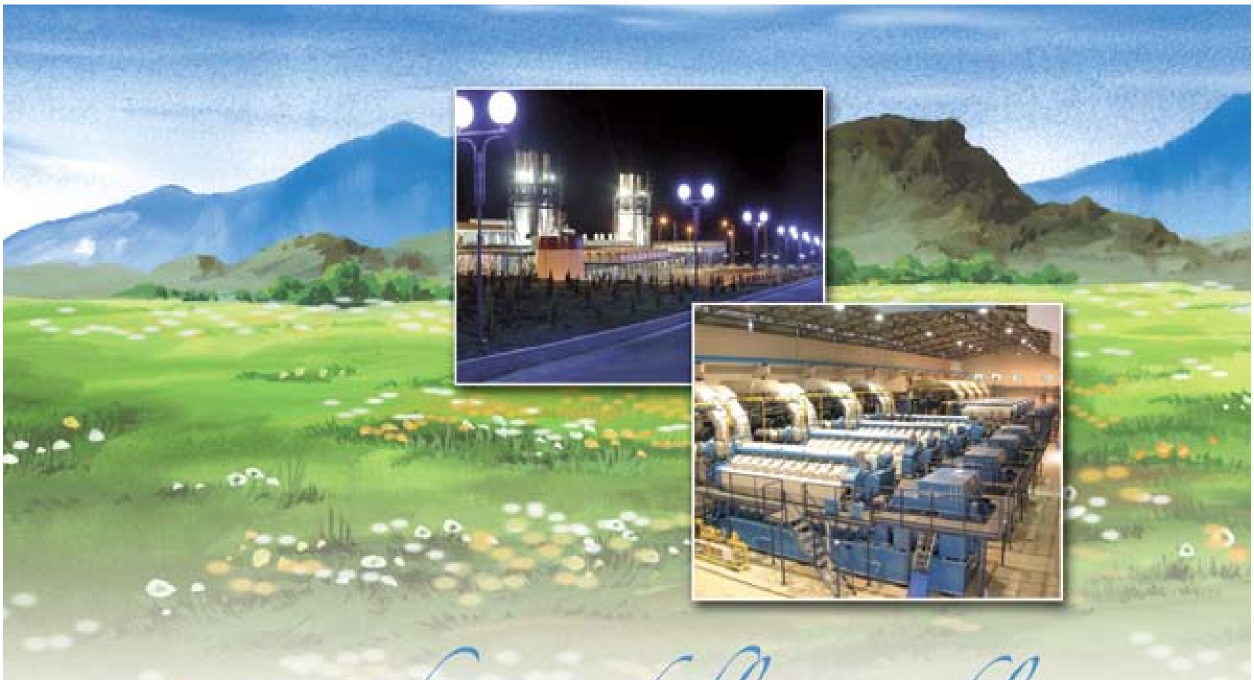


Let a thousand flowers bloom

It all started with distributed generation

If we were to look into the history of electricity supply systems, we would be gently reminded that the first ever power plant was based on the principle of "distributed generation". By 1882, Edison had developed such a concept, and installed the world's first generating plant on Pearl Street in New York City's financial district. Reciprocating steam engines provided the motive power to generators, which produced direct-current (DC) electricity to shop owners and other businesses that used electric lighting as a novelty to attract customers.

Later, alternating-current technology displaced Edison's system, due to its ability to be transmitted at high voltages over long distances with the help of step-up and step-down transformers. This enabled large power plants to come up in locations far away from load centres, but close to the energy resource - large dams on rivers for hydro-electric plants, and coal mine pithead in the case of thermal plants. The three-pronged formula of i) generation from large power plants, ii) high voltage transmission over long-distances, and iii) distribution after step-down near load centres has kept the 'central grid" alive and indispensable for several decades.

India, since 1947

When India attained its independence in 1947, and had to build from a base of less than 1500 MW of power capacity, the same line of thinking was pursued by the planners. The emphasis was on building "temples of modern India" symbolised by large hydro-electric dams and large coal plants. This approach is so well entrenched that even in the 11th five-year plan (2007-12), 75.8% of the planned capacity addition is slated to happen through the installation of large coal plants.

> Natural gas grid has the potential to revolutionise the power sector, if gas is channeled into distributed generation.

There is no denying that a country as vast and as spread-out as India needs all these large plants. Even if we, for a moment, ignore the need to fuel the galloping growth of GDP, we require another 17000 MW just to wipe out the existing shortage between current demand and supply.

In reality, we need much more than that. Let us not forget that 40-50% of the households in rural India still do not have access to electricity and we must correct this situation first. Besides, if we desire to move up the Maslowian pyramid and aspire for "24 x 7" power supply - something, that is taken for granted in developed countries- we must create capacities that exceed existing demand, that provide for future demand, and have reserves built in to take care of various contingencies. The option of load shedding must not be allowed to exist.

That's why we need a strong central grid that caters to all segments of society and that draws upon all resources at our command, - coal, hydro, nuclear, etc.

All is not well with the central grid

But, the centralised system has some inherent limitations and we need to be conscious of that. We cannot be on 'denial mode' when it comes to recognition of these weaknesses.

First, large power plants need large investments. This has often proved to be a major bottleneck and has stalled many a planned project. Not surprisingly, we have fallen short of the targets set in every 5-year plan so far.

5-year plan	Target MW	Installed MW	Achieved %
1992-97	30830	16729	54.3
1997-02	40246	19250	47.8
2002-07	41000	27284	66.5
2007-12 planned	78000		

Second, they are inefficient. The coal plants generate at very poor thermal efficiency (the Indian average has been less than 30%, though some of the new plants will boast a higher figure). The power so generated suffers huge losses (the Indian average is more than 32%), before it reaches the final consumer.

Losses after generation, %		
Year	T&D losses	AT&C losses
2002-03	32.54	32.54
2003-04	32.53	34.78
2004-05	31.25	34.33
2005-06	30.42	34.54
2006-07	28.61	32.07

Source: CEA:Highlights of power sector, Nov 08

Third, these plants are meant for base-load operations, but are ineffective in meeting the peak load requirement that comes up at different hours of the day and during different seasons.

Year	Peak demand (MW)	Peak Met (MW)	Peak shortage (MW)	Peak shortage %
1997-98	65435	58042	7393	11.30
1998-99	67905	58445	9460	13.93
1999-00	72669	63691	8978	12.35
2000-01	78037	67990	10047	12.87
2001-02	78441	69189	9252	11.79
2002-03	81492	71547	9945	12.20
2003-04	84574	75066	9508	11.24
2004-05	87906	77652	10254	11.66
2005-06	93255	81792	11463	12.29
2006-07	100715	86818	13897	13.80
2007-08	107010	90793	16217	15.15
(Upto Jan-08)				

Source: Annual Report 2007-08 of Ministry of Power

Fourth, coal plants have come under intense scrutiny for their high CO_2 emission- a pollutant that is known to be responsible for climate change.

Fuel Emission Factors (EF) (Source - IPCC 2006			
	Unit	Coal	Lignite
EF based on NCV	gCO_2 / MJ	95.8	106.2
Delta GCV NCV	%	3.6%	3.6%
EF based on GCV	gCO_2 / MJ	92.5	102.5
Oxidation Factor	-	0.98	0.98
Fuel Emission Factor	gCO_2 / MJ	90.6	100.5
n/a = not applicable (i.e. no assumption were needed)			
CO_2 emission at station level			
	Unit	Coal	Lignite
Auxiliary Power Consumption	%	8.0	10.0
Gross Heat Rate	kcal /kWh	2500	2713
Net Heat Rate	kcal /kWh	2717	3014
Specific Oil Consumption	ml /kWh	2.0	3.0
GCV	kcal /kg	3755	n/a
Density	t /1,000 lt	n/a	n/a
Specific CO_2 emissions	tCO_2 /MWh	1.04	1.28
n/a = not applicable (i.e. no assumption were needed)			

Source: CEA database

For these reasons, the Indian power sector is under pressure to change the mix of technologies and fuel options, so as to increase capacities rapidly, to improve efficiencies across the supply and delivery chains and to reduce its CO_2 footprint. Quite a tall task, by any reckoning.

Back to Edison

It is in this context that one of the elements of Edison's business model, namely, "distributed generation plants close to load-centres" (although he did not call it that) can be effectively applied. While the term "distributed generation" is technology-neutral, let us choose an option that not only will enable in-situ generation but will also ensure supplies on 24 x 7 basis; not ones that are seasonal or sporadic. Applying this criterion, reciprocating-engine technology emerges as the best choice, as will become evident below.

Distributed generation - the Indian story

The concept of distributed generation using reciprocating engines is not new to India. When you use a diesel-engine in your housing complex or in a factory as stand-by power whenever the electric supply from the utility fails (and it can happen quite frequently), you are a card-holding patron of the 'distributed generation' concept.

But, we are not talking just about stand-by power. As illustration of the ability of "reciprocating-engine based distributed generation" to ensure '24 x7' supplies, we need only cite the example of cement plants in India. Right through the '80s and '90s, when they were expanding rapidly and had to ensure reliability of power supplies, these plants depended almost entirely on captive power produced by medium-speed reciprocating engines that operated at high-efficiency (45%) on low-cost heavy-fuel oil (HFO). Same was the case with other large energy-intensive industries such as textile mills and caustic soda plants. Millions of tons of cement and caustic soda and millions of metres of yarn have been produced over the years using captive power from medium-speed, reciprocating engines installed in situ. So, distributed generation has a long track-record of having powered the industrial production of the country.

HFO-based generation requires that fuel be transported in tankers to the captive power plants and that these plants be located outside city limits. These pose some limitations. To expand the role of reciprocating engines, there is hope however, in the form of natural gas.

Reciprocating engines that run on gas

Reciprocating engines can be designed to burn natural gas efficiently. When medium-speed engines developed for HFO were adapted to run on natural gas in the early '90s, the concept was embraced readily. Far more efficient than the smaller, high-speed gas engines and far more flexible in operation compared to the gas turbines, the medium-speed gas engine is, today, easily the 'best in class'.

Though availability of natural gas has been quite limited in the country, medium-speed gas engines have been installed wherever an opportunity presented itself.

At a group-captive plant at Ramanathapuram, Tamilnadu, located just off a gas well, a battery of ten gas engines each of 8.5 MW rating, delivers power into the grid, for wheeling to consumers spread over the state. Waste heat from the gas engines is used to produce steam that, in turn, is fed into a steam turbine to produce additional power of 8 MW.

In another example, at a plant in Malanpur in Madhya Pradesh, located close to a gas line, three gas engines of 8.7 MW capacity each, deliver reliable power through dedicated lines to captive industrial consumers. The plant also produces steam from waste heat, and the total efficiency exceeds 65%.

National Gas Grid

The emergence of the national gas grid spurred by discoveries off the eastern coast, has the potential to catalyse distributed generation all along its route, if only we can get our act together. Unfortunately, that remains a big 'if'.

Natural gas, being in short supply, has to be rationed. An Empowered Group of Ministers (EGoM) that was entrusted with the task of deciding the order of priority for gas supplies has established the merit order as 1) fertiliser plants 2) existing power plants serving the central grid 3) LPG production and 4) City gas distribution to meet the needs of domestic cooking and CNG for vehicles.

At least, one of the above priorities can be questioned. The decision to allot gas preferentially to gas-turbine power plants stems from a 'central' mindset that is a vestige of the coal-plant era. While gas-turbine plants are more efficient when operating on full-load, as compared to coal plants, power supplies from these plants don't escape the high T&D losses or the inflexibility that characterise the central supply system. Also, they need large investments at one go, and this will hamper the speed of capacity addition.

Gas as an enabler of DG

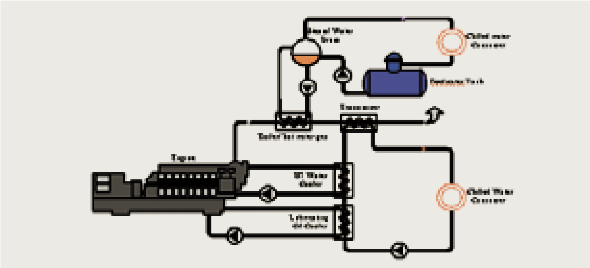
If we can partially let go of the legacy of the central system and look at many, smaller power plants all along the gas grid, we would, at one stroke, enable a multiplier effect. What this would entail is door-delivery of gas to enable production of power in situ, for various applications like:

- Industrial self-generation
- Combined heat (paradoxically, for air-conditioning purposes) and electricity for large commercial complexes, Internet data centres, hospitals and malls
- Peaking power plants to top up the central base-load plants.
- Rapid-response plants to act as the foil for infirm wind energy
- Rural electrification, now very poorly served by the central grid.

Benefits of gas-based distributed generation

All these applications lend themselves very well to the use of medium-speed reciprocating engines and derive the advantages of:

- Efficiency: By higher efficiency of generation and by helping avoid transmission losses, they deliver maximum output per Kcal of natural gas. A national resource is thus put to best possible use.
- Combined heat and power (CHP): As we have seen earlier, reciprocating engines not only deliver power at high efficiency, they also offer possibility of using the waste heat from exhaust and water jackets, to generate steam or hot water that can



be put to good use. For instance, in a commercial complex, where air-conditioning load forms a significant percentage of total power requirement, the waste heat can be used in absorption chillers to reduce the burden on electric chillers.

- CO_2 footprint: The high thermal efficiency, due to the combination of high power cycle efficiency, elimination of T&D losses, and use of waste heat, ensures one of the lowest possible CO_2 footprints among the 24 x 7 power options. Also, by providing the foil for wind turbines, they act as 'enablers' of renewable energy and further cut down the CO_2 footprint.
- Flexibility: As the example of peaking power plants shows, the quick start-stop feature and the rapid-response capability to match the load, impart much-needed flexibility into the system.
- Modularity: The plants based on multiple engines can be scaled up to suit increasing loads over a period of years. This helps in staggering investments and in attaining an optimal plant load factor (PLF).

Conclusion

While the country must step up all efforts to strengthen the central grid and to meet planned capacity additions, the process can be complemented by encouraging distributed generation. The gas grid can serve as the catalyst for this movement, as it has the capacity to carry and deliver clean fuel right at the points of power consumption. Acting like a nourishing river, it can allow a thousand power plants to bloom along its route.

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