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energy efficiency in industrial utilities

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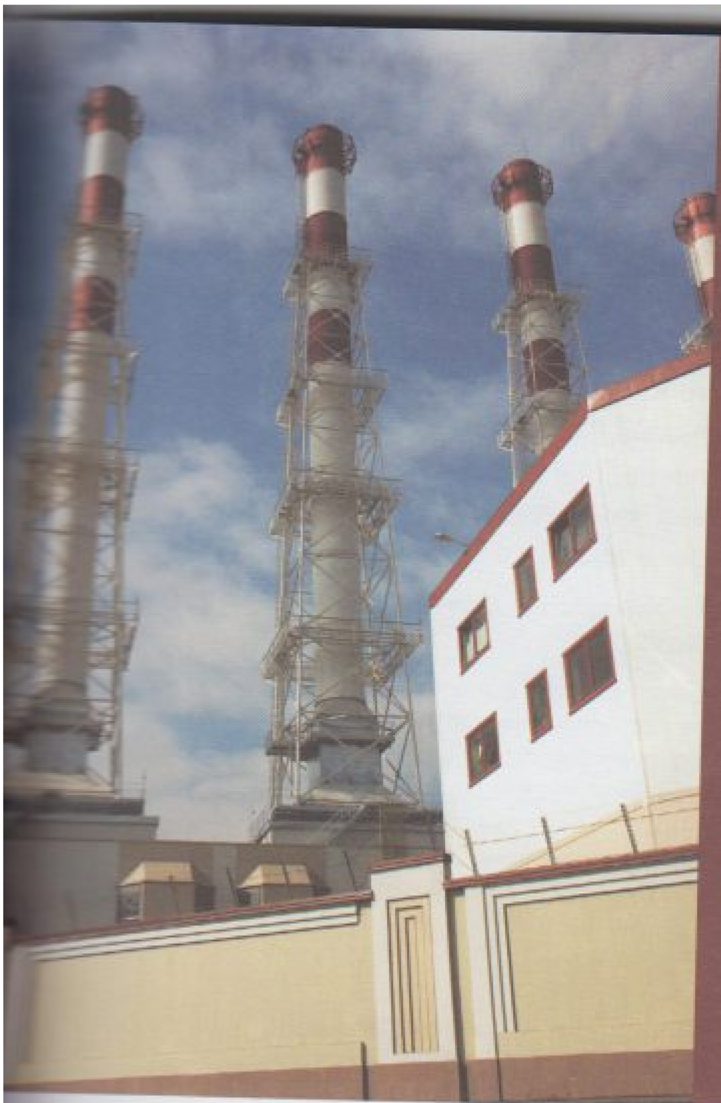

latest developments in off-grid cogeneration applications

Elena Barbizet

Heat recovery systems and thermo-activated technologies are mature technologies, and their reliability has been proven over the years with export of excess electricity to the grid. However, persistent barriers to the dissemination of cogeneration still remain. One option would be to go for off-grid cogeneration. But until recently, cogeneration applications only delivered on their promises in the continuous mode, where electricity is exported at a stable rate to the grid. A French company has recently patented a new system for smart energy regulation. The design improvement from the current cogeneration applications is that every machine involved, responding to a specific need, is considered in relation to the others, in terms of electricity and heat consumption as well as heat rejection.

India's Energy Landscape

The Indian government recently expressed strong concerns about the country's energy situation [1]. Over the past few decades, while dealing with the global threat of climate change, the energy production from the country's own resources and the distribution networks have failed to keep pace with the continuously rising demands of India's fast-growing economy. This induced increasing fuel imports, raising questions about the nation's energy security, as well as a growing pressure on the grids, leading to low voltage and significant capacity shortfalls.

In order to cope with the energy conundrum, ambitious targets have been set by the National Action Plan on Climate Change. Notably, by 2022, 15% of the energy demand is to be met by renewable sources [2]. Legislations therefore provide feed-in tariffs for renewables in order to reach this goal, and smart-grid innovations that are looking at effective integration of technologies into the grids to increase their reliability will certainly contribute to the growth in renewables use.

Even though India's political will is progressively being implemented through various programmes, reliable power supply is yet to reach all across the Indian subcontinent. It remains to be seen whether the economic growth can be met by corresponding investments in energy production and distribution infrastructure. The electrification rate is only 44% [3], and for those businesses in the industry and tertiary sector that are interconnected, back-up generators are considered as standard equipment [4]. But it makes both capital and operation expenditures' burden on private operators significantly increase.

Energy conversion processes like power plants waste more thermal energy than the produced electricity. For every 100 units of fuel, only 35 units are turned into electricity; the remaining 65 units are vented into the atmosphere as heat. If this heat is harnessed, it can meet several needs: heating, cooling, desalination of sea water, etc. This process is called co-generation or distributed generation.

Cogeneration or Distributed Generation: A Solution?

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If heat can be utilized within the vicinity of a power plant, co-generation is an effective option, to generate both electricity and heat instead of discarding 70% of the primary energy source that has been paid for by the community. Whatever might be this primary energy source, it always comes at a price. Be it diesel, gas or biomass, or even a renewable resource, it is scarce, and with the upward trend in prices, energy efficiency is no longer an option but an imperative.

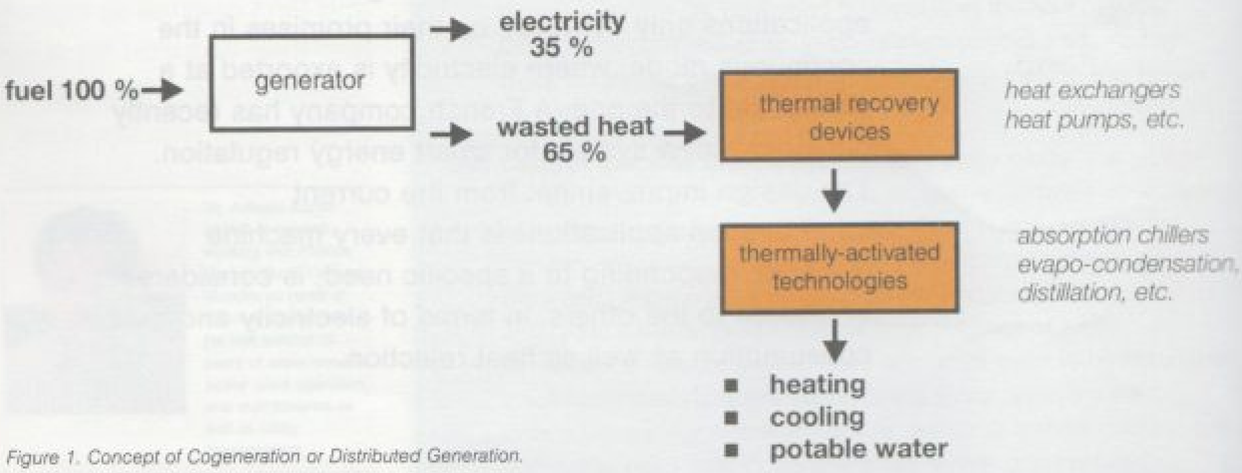


Figure 1. Concept of Cogeneration or Distributed Generation.

To these thermal losses in the transformation process, one must add losses in transmission and distribution. In India, technical and commercial losses amount to about 35% of the transported electricity [5]. If heat can be utilized within the vicinity of a power plant, cogeneration is an effective option, to generate both electricity and heat instead of discarding 70% of the primary energy source that has been paid for by the community. Whatever might be this primary energy source, it always comes at a price. Be it diesel, gas or biomass, or even a renewable resource, it is scarce, and with the upward trend in prices, energy efficiency is no longer an option but an imperative.

This explains why cogeneration makes particular sense in India's energy mix, at one's business level, for costs and reliability can be greatly improved, as much as at the national level. It might be more efficient to generate one's own energy rather than buy it from a grid that is yet to become reliable. Not only the combustion process is in itself greener, for it reduces fuel consumption and pollutant emissions, but the thermo-activated technologies also have significant advantages regarding the environment: absence of refrigerants (CFC, HCFC etc.) to be absorbed or adsorbed, absence of water treatment and fungicides for evapo-condensation, etc.

Trigeneration applications are considered to be state of the art technology: from the electricity generating processes, thermal wastes are recovered so as to provide for hot water and air-conditioning. This constitutes an improvement over conventional generation and cogeneration (electricity and heat). Using heat exchangers, one can reach a global efficiency of about 65%. The heat collected can be used afterwards in different ways, depending on the needs of the facility: space heating or cooling, industrial processes, etc.

Trigeneration applications are considered to be state of the art technology: from the electricity generating processes, thermal wastes are recovered so as to provide for hot water and air-conditioning (Figure 2). This constitutes an improvement over conventional generation and cogeneration (electricity and heat). Using heat exchangers, one can reach a global efficiency of about 65%. The heat collected can be

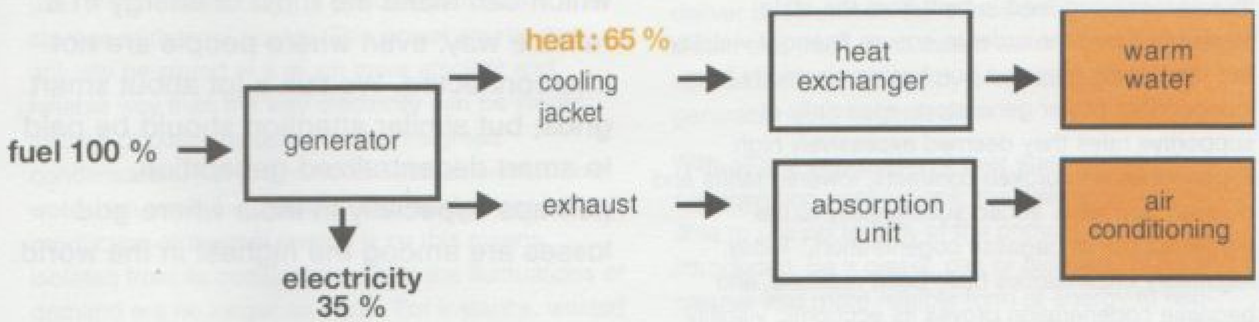


Figure 2. Concept of Trigeneration.

used afterwards in different ways, depending on the needs of the facility: space heating or cooling, industrial processes, etc. Significantly reducing fuel consumption, this energy-efficient application can play its part in the country's energy independence.

Some applications use a Rankine cycle to generate more electricity from the heat, but its efficiency is capped by the general laws of thermodynamics. With the ambient temperature as the cold source, the cycle is not able to reach a sufficient Delta T of temperatures to perform efficiently, especially when compared to the necessary amount of investment.

Barriers to Overcome

Still, there are many reasons that explain why cogeneration and trigeneration applications have not yet reached their full potential. Persistent barriers to the dissemination of cogeneration so far remain: informational, regulatory and technical barriers.

Heat recovery systems and thermo-activated technologies are mature technologies, and their reliability has been proven over the years with export of excess electricity to the grid. When the electricity output stands stable because electricity is sold to an operator, the by-produced heat is also stable, and cogeneration applications deliver on their promises. This considerably eases the process and explains how most cogeneration applications export excess electricity to the grid.

Informational barriers explain why the private sector remains largely unaware of the technology, which is still considered to necessitate high technical skills. Demonstration projects, training and workshops performed by Cogen India [6], for instance, or the Ministry for Non-Conventional Energy Sources [7] nevertheless have improved the overall awareness.

Regulatory factors also prevent the rapid uptake of the technology. As Yaha et al. [8] recall, when the technology was being introduced in India in the bagasse industry, investments needed to be made that necessitated feed-in tariff from the state electricity boards in order to ensure financial viability. But the boards "resisted purchasing electricity from independent power generators, especially at supportive rates they deemed excessively high. Experiences with broken contracts, lowered tariffs and delayed payments added substantially to the perceived risk of bagasse cogeneration." Today, regulatory uncertainties have been reduced, and bagasse cogeneration proves its economic viability when electricity is exported to the grid and heat used by the local community. Delays in administrative procedures nevertheless remain, which explain why the private sector bothers with biomass cogeneration only for large-capacity plants, namely, 15-20 MW.

This is unfortunate for the thermo-activated power generation landscape, which has considerably evolved. From a generation capacity of 500 kWe, viable return on investment can be reaped in Indian southern states, where there is a relatively stable demand for heating and cooling throughout the year. Competition among manufacturers across the world also contributes to lower prices for small-capacity cogeneration plants.

When the electric output stands stable because electricity is sold to an operator, the by-produced heat is also stable. However, when off the grid, electricity needs vary throughout the day and independently from the heat requirement for cooling, warm water or desalination.

Off-grid cogeneration barriers

One option would be to go for off-grid cogeneration. But until recently, cogeneration applications only delivered on their promises in the continuous mode, where electricity is exported at a stable rate to the grid. When the electric output stands stable because electricity is sold to an operator, the by-produced heat is also stable. However, when off the grid, electricity needs vary throughout the day and independently from the heat requirement for cooling, warm water or desalination.

Things could change with the latest innovations in dynamic cogeneration, which can make the most of energy in a reliable way, even where people are not interconnected. We talk a lot about smart grids, but similar attention should be paid to smart decentralized generation, perhaps especially in India where grid losses are among the highest in the world.

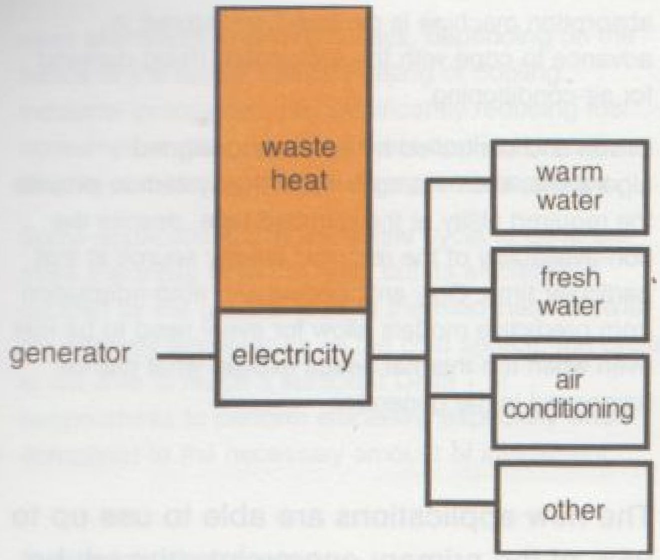
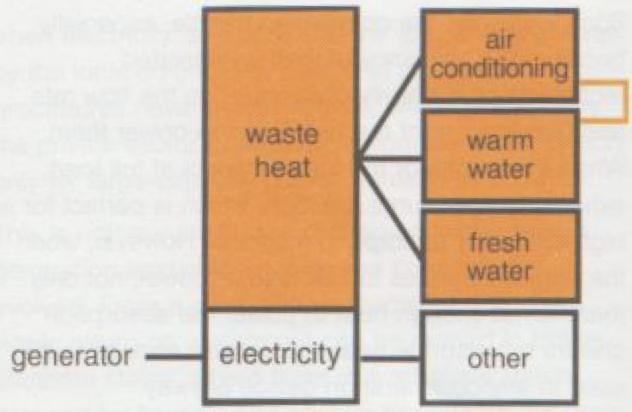


Figure 3. Enhanced Heat Recovery for Decentralized Generation.



resort hotel located in a climate similar to that of Eastern India could save 30% of fuel per year with a payback period of less than 4 years. Similar savings could be reached in residential or commercial facilities like hospitals, business centres, and shopping malls, as well as in industries like pulp and paper, food processing, refining, steelwork and so on.

At the end of the day, only a diversified energy mix, responsible energy consumption and efficient energy conversion processes can enable India to better cope with climate change and the growing pressures on energy production and distribution.

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