

## **CHALLENGES IN IMPLEMENTING DISTRIBUTED GENERATION PROJECTS**

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The recognition of climate change as a growing threat to all countries, and the surge in demand for fossil fuels among strong as well as growing economies has compelled countries to develop action plans to mitigate the effects of climate change by reducing the emissions of greenhouse gases. The latter has given rise to increases in the prices of fossil fuels (both oil and gas) due to a widening gap between supply and demand, especially in growing economies.

The situation is further complicated by the need to secure long-term supplies of energy resources to sustain national economies and their growth rates. These two factors could well be the change agents which determine how future generations will utilize energy. Energy planners need to think out of the box and reconcile with fast changing realities to develop meaningful long-term energy roadmaps. These trends seem to bode well for decentralized energy (DE) technologies such as:

- decentralized generation of power from waste heat or waste gases produced from industrial processes
- high-efficiency cogeneration or combined heat and power (CHP)
- distributed generation using renewable resources for local consumption of electricity.

Since DE technologies can make use of either the energy that is presently wasted in the form of heat or renewable energy for electricity production, they are therefore less susceptible to external factors of oil price fluctuations or the anticipated stringent regulations in response to climate change concerns. DE technology projects, based on resource availability and located near the points of energy consumption, are emerging as the favourites to meet the captive energy demand in many countries across the world. The advances in technology options for electricity production made during the last few decades are now benefiting the power industry and households in rural areas. This is beneficial for areas which due to technical and economic reasons do not have or will have access to grid electricity. In many of the new technologies such as mini and micro-hydro, the environmental issues are minimal and can be easily controlled.

### **THE ENERGY CIRCLE**

A quick look back at the evolution of energy systems during the past five hundred years reveals that energy supply systems during the 15<sup>th</sup> and 16<sup>th</sup> centuries are fairly representative of the past several centuries. For the sparse population then found across the globe, resources such as biomass and, in a few places, coal provided all the energy needs. The main source of fuel supply (i.e. wood) was not too distant from the point of consumption compared to today.

Later, as word of the “rock that burns” spread, the use of coal increased and supplies augmented to match demand marking the beginning of the coal era. However, due to the lack of coal availability in certain locations, biomass continued to be the mainstay in these regions until the beginning of 20<sup>th</sup> century.

The technological developments in subsequent centuries, which need no elaboration, helped to increase the distance between source and points of energy consumption. Finally, the separation became a permanent feature with the advent of electricity transmission systems which gradually displaced past forms of energy end-use devices across large geographic areas. The separation increased even further rapid growth in the use of petroleum since the mid-20<sup>th</sup> century. Thus, a shift took place not only in the pattern of energy consumption, but also with respect to energy availability near the point of use to a more centralized location.

The convenience offered by the end-use of electricity triggered a demand which grew in geometric proportions, causing governments to invest heavily in infrastructure, delaying access to end-users by several years until the wires were drawn and charged. In many growing economies, states are still unable to meet this target. Providing electricity in many remote locations is not economically feasible and despite the fact that advancements in electricity production from centralized locations continue, there is a large, scattered population estimated at close to two billion people across the world that still does not have access to electricity. This phenomenon highlights the limits of centralized fossil-fired energy systems. Having identified the outer limits of centralized generation systems, a boundary can be drawn around them, which makes the job of dealing with the challenges of decentralized energy systems much easier.

## **CROSSING THE TECHNOLOGY BARRIER**

Advancements in technology as well as unforeseen factors in the past few decades are now exerting pressure for yet another shift in the pattern of energy supply and consumption which hopefully can provide an optimal solution for the coming decades. Consumers have started looking at either the options available locally or alternate sources to meet their energy needs. Industries that are the biggest consumers of energy have started looking at options of locally generating electricity to meet their needs due to economic or environmental compulsions. In such cases, the availability of appropriate cogeneration technologies and their integration to the industrial process both play a crucial role.

Traditionally, industries have been the main users of DE technologies primarily to help improve their bottom line. Industry has invested in DE projects of various sizes, irrespective of the process. Captive power units running on fossil fuel are preferred as they provide complete flexibility in terms of matching energy needs, meeting future growth requirements, and offering the quality and reliability of electricity which are much sought after in many developing countries where industries are starting to compete globally.

Globally, there are several examples that support the above point. One set of examples are the cogeneration projects in Indian sugar mills which added a whole new chapter in technology and promoted unique business models in the renewable energy sector, as well as the sugar industry. In these projects, sugar cane waste or bagasse, is used to generate

electricity to meet the energy needs of the sugar mills, with excess power supplied to the grid. These are the conventional technologies of power generation where, instead of a fossil fuel, crushed sugar cane waste is burned in a boiler to produce steam at high pressure (66 kg/cm<sup>2</sup>), and is then passed through a condensing extraction steam turbine to generate electricity. Depending on whether the sugar mill is operational or not, the steam turbine is run in extracting mode or condensing mode.

## **CASE STUDY**

### **The Alternative Bagasse Cogeneration Programme of USAID**

To encourage increased and efficient use of biomass and sugar cane waste (bagasse) at sugar mills, USAID/India launched the Alternative Bagasse Cogeneration programme in 1995. Support was provided in the form of grants and technical assistance to nine private sugar mills that came forward to invest in cogeneration.

USAID engaged the U.S. Department of Energy's National Energy Technology Laboratory to provide technical assistance, supervision, training and performance evaluation, and the Industrial Development Bank of India to manage the project's investment-related activities.

USAID offered a conditional grant of US\$40,000 per MW to the private sugar mills for installing and operating high-efficiency biomass cogeneration. The size of cogeneration plants ranged from 12 MW to 24 MW. USAID's commitment helped nine private sugar mills to achieve financial closure with the banks at commercial terms.

The partners worked together to overcome difficulties in project implementation and signing power purchase agreements with local utilities. They also set a precedent by demonstrating high-efficiency 270-day cogeneration using sugar cane waste and other biomass fuels. Aggregate capacity of 195 MW was added as a result of this effort and the units are feeding power into the grid to this day. More capacity addition is taking place on purely commercial terms throughout India. Since the ending of USAID assistance, a total of 600 MW of capacity has been added in the sugar sector.

### **OVERALL BENEFITS FOR DEVELOPMENT**

Because both steam and power are utilized locally in the sugar mill, the thermal efficiency of cogeneration is significantly higher than that of centralized fossil fuel-based power plants. Such cogeneration qualifies as a DE application project as it has small capacity, which provides uninterrupted power to nearby rural areas, thereby minimizing transmission and distribution losses.

Due to the improved reliability and quality of supply, farmers and other end-use customers in villages also benefit greatly as cogeneration supports employment and provide regular income to local farmers and labourers.

USAID's equity contribution leveraged 20 times more from local banks and project developers to meet the project cost. Active participation of a number of local banks by lending to these projects helped in building their capacity to understand the bagasse cogeneration business. The presence of engineering firms, equipment suppliers and banks also helped in ensuring continuity of the concept after USAID support ended.

Biomass cogeneration projects using renewable fuels are environmentally friendly and carbon-neutral, in contrast to coal-fired power generation which is a source of high levels of particulates such as sulfur, nitrous oxides and other greenhouse gases.

It is estimated that these nine projects have helped to avoid more than four million tonnes of carbon dioxide (CO<sub>2</sub>) emissions in India.

The success of bagasse cogeneration came not only from the proven technology, but also from a *sound business model* in which the sugar mills had access to a steady revenue stream from the sale of electricity to the utility. This income helped sugar mills to overcome inherent fluctuations in the sugar market (which had an effect on the price of sugar and the mill's bottom line) so much so that some sugar mills considered themselves to be in the business of producing electricity in which sugar was a by-product.

Another Indian example of industrial cogeneration application is a large copper smelter business located in southern India. The business owner(s) made investments in a waste heat recovery system that captures heat from various process streams to generate electricity meets its own requirements and reduce the burden of using fossil fuel. In this case, the management reviewed the overall plant process and identified various streams where energy was being lost in the form of heat. Electricity generation using waste heat helped the company achieve energy independence by going off-grid. This smart decision by the management has helped to meet the plant's own energy demand and reduce energy costs, thus allowing them to market their product at very competitive rates.

Notwithstanding the commercial benefits of CHP derived by industries, as the technical and economic feasibility of CHP projects become more attractive, non-traditional areas have started gaining ground, such as municipal waste-to-energy and biomass gasification-based village power. Today, municipalities, government-owned industries and non-governmental organizations (NGO) are seriously pursuing such projects. This is particularly so as the sale of carbon is becoming a reality and considerably improving the economic feasibility of such projects.

These are some of the examples of the growing list of diverse organizations and projects that have started taking advantage of distributed generation technologies, to either improve the conditions of their businesses or simply to improve the quality of life by providing energy in the form of electricity and heat to end-users.

One would think that after such glaring successes and compelling rationale, there would be a snowball effect leading to proliferation of DE systems across the world. However, challenges remain, such as unfavorable government policies towards DE or the administered prices of fossil fuel or electricity, both of which favour conventional energy models of centralized power generation. An even more challenging puzzle is that of developing a viable business model around some of the DE technologies especially in the rural areas; this is due to the lack of a single ownership and collaterals which, besides a steady revenue stream, makes it difficult to finance a project. As noted before, there are two principal users of distributed energy sources – the industry and business establishments, and retail users who do not have access to grid electricity.

## **CHALLENGES TO FINANCING DECENTRALIZED RURAL ELECTRIFICATION PROJECTS**

There is a far greater challenge in justifying DE projects in developing countries, particularly in rural settings to provide electricity to meet the basic needs of village dwellers that do not

have access to grid electricity. Here, the challenge is to work out the economic viability of the projects which is often more important than the limited choice of site-specific technologies. Limited rural income generally can only cover operating costs and some equity, leaving the majority of the initial capital expenditures to be supported in the form of grants from local government or development agencies.

The starting point still remains the assessment of a suitable technology option which can be managed by the local community. This means that both business and technical capacities of the local community must be built to operate and maintain the energy system. Unfortunately, for such applications in remote locations, the most suitable of all technologies (solar photovoltaic or SPV) turns out to be the most expensive and is therefore a less desirable option. Small diesel-generator (DG) sets, which are much cheaper, offer electricity albeit at high cost to end-users. Currently, a biomass gasification system coupled with a gas engine is emerging as another attractive option and stands in between the other two technologies. This technology uses gas rich in methane produced from biomass gasification (not combustion) which after clean-up is fired in a conventional compression ignition dual-fuel engine. An alternator linked to the engine produces electricity.

In rural village settings, there are three major problems for DE technology application:

- The issue of capital versus the running cost. As noted above, SPV has a very high cost but a low operating cost, while DG has a low capital cost but high running cost. If the technology selection is made based on capital cost, SPV will lose out, despite the well known fact that the cost of per unit of electricity is computed much higher due to high combined capital, running, and maintenance costs of DG systems.
- The issue of sizing of DE systems. DE systems are often sized to meet the lighting needs of the local people with very little spare capacity to meet any other additional demand of electricity. For a project to run successfully, the capacity calculations should take into account load growth over a five-year period, as the factors that can trigger sudden increase in demand of electricity are unpredictable. During the initial years when demand remains low, an alternative is to increase the generating capacity in a phased manner.
- The issue of financing DE systems. Clearly this issue is closely related to the previous two above two issues, and therefore it is imperative that the first two issues are carefully resolved. If the finances are made available in a phased manner to meet growing demand, the chances of rural DE project becoming successful and self-sustaining will greatly increase.

Governments are slowly coming forward with creative ways to support DE. However, the gap between government subsidies and the true cost of a project can at times be too wide to be bridged by local users. Special-purpose models are being created to clearly delineate the responsibility of the local community in terms of ownership of assets through shareholding, operation and maintenance, and payment mechanisms. These models still need to be standardized, improved upon and tested across several different locations before they can be widely applied.

A number of technologies are nearing maturity and stability, but the business models are still being refined. A few critical elements that should spur the development of such projects include governments taking a share in the project, the involvement of private sector equipment providers, NGOs interfacing with the village communities, and lending by local banks.

Some of these elements have been time-tested in DE projects in remote regions in India. The majority of these projects have used SPV technology, while, and a handful in recent years have used biomass gasification. Led by the local government agency, several DE projects of 50, 100 and 150 kW sizes were trialled and tested over a period of seven years, and two technologies are functioning successfully. With the help of local entrepreneurship, the lives of more than 10,000 villagers have now been greatly improved by obtaining access to electricity.

Banks have a major role to play in DE projects, both in terms of increasing the geographic coverage and in getting these projects off the ground. So far DE in villages has failed to enthruse banks for the reasons cited above. Banks and other financial institutions are guided predominantly by their business interests and prefer to lend to those industries where they see a secure and steady revenue stream needed to service a loan.

In successful DE projects, a steady revenue stream may not be generated until after a period of about three years. Few lenders have the patience to wait this length of time. Banks and financial institutions have their annual disbursement targets to projects, which are achieved by financing large-size projects where the transaction value or the loan amount involved is high. Thus small-size projects never come onto their radar screens. Consequently very few banks think about supporting DE projects. The handful of those that do continue to remain extra cautious in their approach.

The financing of village DE projects is in its early stages and is still evolving as the situation of energy needs, suitability of technology, and willingness to take ownership of energy systems all vary from one place to another. It is at a stage where it needs government attention and perhaps – in the case of developing countries – support from bilateral and/or multilateral agencies, through equity participation rather than providing capital subsidy which causes distortions in the market. In the bagasse cogeneration projects, USAID's contribution was below 10% of the overall project cost, but with equal emphasis on training for the sugar industry and banks, the concept has today spread throughout the country and is working without any additional financial support from the development agency of the government.

As DE projects in rural areas rarely offer returns attractive enough for banks to seek engagement, banks are still cautious in their approach and their commitment remains to be seen. The involvement of banks can be facilitated by bundling several such projects, which helps to reduce transaction costs especially for those banks already working in the rural sectors and can relatively easily include a portfolio to finance DE projects. The presence of DE in rural areas can strengthen agricultural activities and improve the incomes of the end-user – a viable win-win scenario. Therefore the bottom line remains that local banks and financial institutions must be in the forefront and where ever required, and their capacity

should be developed so that they can in turn build the capacity of local people, creating opportunities for local franchises to increase the off-take of DE projects.

## **CONCLUSION**

The Indian examples illustrate the fact that the opportunities for DE projects are present across the industrial and commercial sectors in varying degrees in all developing countries. External compulsions are now forcing government and end-users alike to exploit the latent energy in their backyards. Having recognized the limitations of centralized energy supply systems, governments should come up with policies favouring DE systems. Governments should further encourage end-users to identify and develop resources and feedstock for their respective DE projects. They should also encourage local financial institutions to support such projects, especially for the retail end-users, by helping to minimize the risk involved in such projects through equity partnership.

Given the significant advantages which DE offers, particularly in minimizing the waste of energy in the form of heat and avoiding transmission and distribution losses, it is in the best interest of governments and industries – the two major stakeholders – to make use of DE systems to meet their respective goals now, or face the peril of losing out to the competitors.

A shift toward DE today is a leap forward, yet it is also a return to the old way that generations before us met their energy needs on-site. The difference though lies in the fact that the present change is based on an informed decision and utilizes diverse energy sources. Today, the technology choices of energy production and utilization are far superior and more efficient than they were a century or even a few decades ago. The sustenance and growth of an economy will strongly hinge upon the extent of use of DE in the future, with centralized energy systems serving as the backbone. Ultimately, the overall shift to DE will greatly depend upon the end-use efficiency of energy. In spite of these uncertainties and limitations, the future growth trend of DE is optimistic since it offers the right mix of technical and economic solutions to meet growing energy needs at the grass-root levels while addressing global climate change.