Sustainability and Institutional Buildings

Sustainability provides rational solutions for habitat, measurable and evaluated over time in maintaining conditions for those who organically integrate with the environment, say **Ar. Venkat Peesapati** and **Dr Massimo Vianello** as they discuss the plan of an institutional building.

Overcoming Space and Time to Create a New Classic

It is a general belief that the task of architects and planners is to work with space rather than time. In fact, the challenge should be to defeat time by creation of buildings that remain timeless and efficient. In doing so, they overcome the risk of premature ageing of a building, as trends overlap in a society based on the increasing exponential speed of information.

Think about Palladio who built his Ideal on Greek architecture—which he had actually never seen, but animated his vision with vitality from the texts of Greek philosophy, the admiration showed by the Roman architects and from the stories of sailors which described the beauty of ancient temples. Palladio was looking for originality in architecture and thus, he created the most innovative vision and successful buildings for his contemporaries. What is relevant today, often is seen as outdated later, with no hope of attaining the most coveted goal for the creation of a building—of becoming 'classic'. In this regard, the Capitol in Chandigarh and the Barcelona Pavilion or the Bauhaus in Dessau are exemplary 'classic' buildings.

Today, everything is immediately viewable with a 'click', so too, our ability to imagine may be changing and possibly diminishing. We devour images, and thus evidently appreciate those buildings that we feel represent our time.

Reference to ecological issue is made in many forms of architecture today; for example, by increasing the vegetative cover on the building facade, and even covering all facades with flora, with an interesting example in Hyderabad. What is important to consider is that a building manifesto, while relevant to fix an arrival point, might have no influence on the wider scale of the real problems. The city needs monuments as extraordinary episodes, but these are only readable as such if imposed on a texture of repeated elements that can sustain such exception. The ordinary buildings that really shape the city are those where we will play our next challenge in terms of improvement of the quality of our habitat.

The best architecture aims to break the vicious cycle of consumerism on the use of the images of buildings that we persistently see invading the streets, where every building is competing with the next, instead of creating harmony on the whole. This is what we see from the outside, on the facades. The building production mechanisms are in fact governed by economic factors, which remain under the skin of the buildings, hidden by the play of reflections and transparencies but deeper effects are then seen, sometimes needing generational rotations, on the socio-cultural economic fabric.

Institutional buildings are integral to the city, and a discussion of them would be incomplete without an examination of the concept of the city in which they exist.

'City is more than a place in space; it is a drama in time'

With this proverb (1904, i.e., one hundred and ten years ago), Patrick Geddes inaugurated one of the most important steps in the definition of urban studies, which led him to substantiate his research on Indian cities in the following two decades. It is an element of interest that the thinker who has deeply inspired architects and planners in the post-war generation of change, found his most fertile field of application in India. The texture and vitality of Indian cities created a profound motivation in Geddes, almost as if physical distance as well as climatic differences creates the emergence of the foundational laws of urban aggregation that could be recognized as universal value.

The city is one of the most important ways in which we express our culture and heritage. Architects and planners have the dual task of promoting its development and defence of values. Often, these positively ambiguous roles—to protect the identity, and at the same time to produce the modifications—are experienced as a professional frustration in witnessing the gap between intentions and outcomes. Architects however sometimes have produced achievements of exemplary synthesis, just as poets, by analogy, are altering the language 'with poetic license' and at the same time, giving us lexis of permanence to hand down from generation to generation.

More often though, the debate in architecture and urbanism creates different fields of belonging inside the same field where different points of view are compared. To explain these aspects, it is of help to see how in the past, similar positions to the present have prevailed, and how a historical perspective can have the strength to remove a deadlock, thereby, revealing a brighter future.

The City and the Road

We take as an example, the debate about the road in the Indian city as it is understood by Lutyens in the master plan for New Delhi and compare it with the position of Patrick Geddes, in the course of his reports for several Indian cities. Lutyens' plan is based on the emphasis of unending roads as an ordering element, that entrenches the aesthetic of the wide road that is still dominant and has contributed to the prevalent strategy of demolition or road-widening that is still widely practised.

A century ago, Geddes insisted on abandoning this practice by promoting 'conservative surgeries' to bring the sections of roads to a human scale, arguing that 'the road must serve the people and not vice versa'. While the 'man in the street' and his needs and deeds are the fulcrum of Geddes' planning, conversely, the demonstration of the power of institutions on the individual are what have determined the scale of Delhi's urban plan.

Today, we no longer have to demonstrate this power but addressing infrastructural aspects—such as mobility—tend to prevail in homage to an idea of progress that transcends the actual quality of the spaces we inhabit.

This effort to understand the fate of the city is preliminary in considering the role of 'institutional buildings'. It is not marginal to the theme that we want to deal with, but it is the essential point. In fact, the understanding of the future of institutional buildings is linked to the role that they play in the organization of the city. Institutional and collective buildings, together in a wider definition, are the seeds for the growth of the city, as we read how, in different ages, palaces, temples, or schools created the core of the origin of our cities, around which they developed and evolved.

Defining Private and Public Spaces

The driving principle, in the case of Symbiosis Campus in Hyderabad, was the idea to simultaneously create a small town and a large building. A universal principle of bringing characters of the city into the architecture of its buildings runs through all ages, in various contexts.

The concept of green building was being considered right from the design stage. To reduce negative impacts caused by the use of automobiles, public transport was encouraged. The project site is located within 800 m of a public bus stop from the entrance of the campus. The project site has access to basic amenities. Most of the amenities are available within the site. The project is designed to be user-friendly for the differently abled and for senior citizens. The site contour of the project has been retained for almost 100 per cent of the total sites, including building footprint. The existing natural water body and the *nala* in the site were retained. The architectural design and philosophy have played a major role in the design of the campus. Construction activity pollution prevention was one of the considerations of the project to achieve sustainability. To meet requirements, few strategies were adopted:

- The top soil was collected, preserved, and reused for landscaping purposes.
- To prevent soil erosion from vertical surfaces of the excavated areas, cement bags were used to retain earth.
- Water sprinkling at regular intervals was done to prevent air pollution.
- Jute bags have been used during construction for curing purpose to reduce the consumption of water for construction activity.
- All rainwater was channelized into existing *nala*.

To minimize heat island effect so as to reduce negative impact on micro-climate, the project has used high SRI paint over 100 per cent of the exposed roof areas. The project will be using Sunsheetal high albedo paint with SRI value of 85.

The key decision was to avoid air conditioning, so passive architectural techniques were adopted to minimize environmental impacts. The elements that were stressed on design were window placement, glazing type, quantum of glazing, insulation, shading elements, and courtyards.

- All windows have a projection factor of 0.5 or more for all blocks.
- Light shelves and air circulation analysis has been incorporated in design as passive architectural design measures.

This expanded the level of freedom in the organization because now it had open corridors which were well ventilated. This led to a drastic reduction of technological components because less than five per cent of the activities were then equipped with air conditioning. It has enriched project opportunities, eliminated the option of adopting expensive finishes like curtain walls because they do not give enough ventilation and promote extra attention in calibrating the openings varied between the side and top. It obviously reduces the depth of the building and this automatically means more consistent natural light everywhere. The other area of attention was not only to increase the ventilation but to ensure that the sun was absorbed correctly at points where it only shows its smile in the morning, and avoids an angry grimace in the afternoon. This was masterfully illustrated by Le Corbusier, primarily in his drawings and finally as a legacy for further generations in the Tower of Shadows. The implications for an architect, of not relying on AC are liberating and allow for the concentration of attention on relevant necessities to create buildings that can 'breathe' and react favourably to their environment.

Once this spirit is established, other components are investigated with the same design behaviour. The harvesting of rain water is done by letting water flow from the external ring of the big roof down through a continuous spout in order to be collected at ground on a wide trench for percolation into the soil.

The students arrive at the Campus during the monsoon time so this external continuous ring of water becomes a lively and surprising element of mediation with the landscape. Almost 30 per cent of the site has been covered by landscape. The fusion of rain, wind, and sun has been worked out as a single question from different, but converging points of view.

Light, ventilation, and protection from meteorological conditions have been contained and yet at the same time, left free, in analogy to the aim of education as a blend of discipline and freedom. Natural elements in some conditions are left relatively open. For example, the external balcony whose only role is to protect the classrooms may become wet in case of severe storms. It would then lead people

Symbiosis-wind flow

to move along the inner balcony which because it is protected by a vast canopy, will always be dry and extend its shadow generously onto the central courtyard. The rainwater harvesting system for the project is designed to capture and harvest rainwater for at least 15 per cent of the average peak month rainfall.

Where one would expect to find the facade, it has been translated into an empty centre, which is the pivot of the architectural composition. It is a rounded portico inspired by the 'Gymnasium'—the ancient Greek space of education from which first steps in the evolution of knowledge were made. The front of the main entrance is dissolved in a porch where the protagonists are not weak or arbitrary architectural signs, but people moving. The functional consequence of overthrowing paths outside and having the classes look towards the courts is the typological choice that has carried the other design choices.

Creating a circular route implicitly gives different conditions of light and ventilation and further variations as we move from the inner to the external balcony. This flexibility of use has been promoted to avoid corridors, thereby giving infinite different paths, as there is always an alternative route. Even in the administrative block with its linear distribution, where the central corridor had no valuable option, it was decided to double in two arms and insert the ladder in the centre. In this way, the central staircase still allows light to penetrate the inside and provide an additional source of ventilation.

The density and placement of buildings allows for a multitude of access routes which serve a twofold purpose. They can not only be used as service areas but also allow for future planning. So, different degrees of freedom of movement are appreciable overall in institutional buildings and in our case the intent is to disseminate the segregation on other part of the building, inspiring a sense of protection and exclusivity.

And where these sentiments would be manifested more deeply, if not in the library! It is a place where everything needs to be safeguarded: the books and the isolated environment, where peace and concentration prevail both inside and outside. As you enter, you perceive the exceptional nature of the place and behave accordingly. There is no need for signs urging people to remain silent. The entrance is secluded, only for people motivated to enter, and once inside, the view is that of rounded walls covered by books. Light, the most useful tool to influence our feelings, has been indirectly filtered and allowed to slide freely along the walls when coming from the north and east, or otherwise has been rejected.

The library contains the seed of the design principles which are then processed in the entire building complex. The part and the whole ensure the spatial identity of each function and give unity of purpose throughout. As a fabric consisting of warp and weft, where the labour employed to weave vanishes, what remains is its design. To explain this project, we have chosen to highlight environmental factors and in particular the turnaround, given the fact that we have had all the privilege of contained air conditioning. The use of air conditioning is restricted to specific areas. These include computer labs, because of the presence of servers and reduction of direct light which interferes with the display and the management area, where visitors may misconstrue the lack of contained air conditioning as a sign of inadequacy, thereby harming the prestige of the institution.

It is instead a prestige for architects and for most progressive engineers to work on buildings that do not require air conditioning. It offers a tremendous degree of freedom of not having to close every part with glass and to work with continuity of space between the inside and the outside, which traditionally are the coveted threshold of pleasantness and architectural character. Obviously summer heat may produce critical conditions with the potential to comport student performance. A balance must be found to drastically reduce energy waste in a country where energy is a precious commodity. It is important today to give value to buildings that do not require air conditioning to motivate further research in the direction of passive cooling which may be a real challenge for the future.

While not wishing to criminalize the use of AC—because this would be Luddite and outside the norms of most basic professional requirements—we insist that the mindset assuming that a building without AC has been poorly planned or is an architectural oversight, must be changed. The AC-free building should be appreciated as a new innovation to be built on in the future. Air conditioning should be seen as a 'Pharmacon'—a drug or active ingredient which is both poison and remedy at the same time. It should be taken with discretion because sometimes necessary but sole reliance can bring about more damage

to the body than benefits. In short, we should exercise caution considering the addiction it causes. There will be no power to cool down the world if we follow the US standards of its use, in which case we face even greater trouble. The reduction of energy consumption in buildings should not be seen as limiting or compromising the comfort and quality of the buildings if it is compared to the negative side effects we could experience in the future if we rely on its use.

It is exactly the indiscriminate use of mechanical means—such as air conditioning, which block Architecture's potential to resolve problems. Look at the increasing number of curtain walled buildings which remain indifferent to the sun caresses or disfigurements.

Points for Thought and Implementation

Encourage the use of verandah, terraces and any kind of covered or open space that produces protective layers between the outside and inside. This can be achieved without integrating open spaces as part of the design and not merely stipulating setbacks. Fix a maximum percentage of a glazed surface on the exterior of the building. Differentiate the percentage of open spaces, relying on the use of building, for example, the percentage of open space for an executive-office building in a very prestigious central area doesn't require to be the same as in a residential area, where open spaces are needed much more and allow for more freedom inside the plot, so as to promote the use of courtyards.

Buildings with progressively increasing thickness, to optimize the land surfaces, bring about not only indiscriminate use of air conditioning, but also create a need for artificial lighting during the daytime. It produces forms of architecture that are increasingly poor and abstractly detached from their context in the name of the misunderstood meaning of progress, recently linked with the glittering powerful shine of glass buildings. Today, we understand the technical reasons of this gigantic hermetic box of glass, but probably it will not be easy to explain to coming generations, the 'why', for so many of the buildings we have built today, as they will be the ones paying the price of this indifference. EF

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Microgrids
The Solar Way

In an interesting discussion, **Dr Suneel Deambi** says that India seems to be on the brink of a microgrid revolution of sorts while considering a dire need for providing energy access to the farthest of inhabited locations.

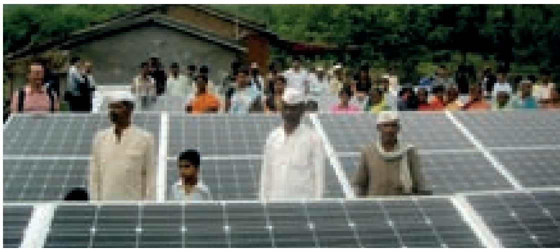
The memories of neatly swept courtyards, not of an imposing size in any manner, in the distant hamlets of Uttarakhand still mesmerize me. The concept of '*Swachh*' surroundings was loved by its inhabitants too but they had no *swachh* toilets to use, then. Additionally, any member of the family travelling to the plains, used to remain out of bounds till his surprise return back home, at times. I used to be there for assessing the overall suitability of small village power packs under a Ministry of New and Renewable Energy (the then DNES) supported project at The Energy and Resources Institute (TERI) in the early 1990s. These power packs run by the Solar Photovoltaic technology ranged in the capacities between 2–10 kWp. Each household had an indoor light with community-based street lighting and television facility benefitting the captive population. Looking back at the Solar PV system, brings it within a close fold of the definition that a modern day 'microgrid' has. Even then, the hapless beneficiaries paid a meager amount for the caretaker's monthly wages. The caretaker was a chosen member of the community trained by the system installation agency in a limited manner It now sounds incredible but true to see a village headwoman connecting to her kith and kin many hundred miles away. Fetching water on a daily basis is a ritual filled with cumbersome effort. Commuting to the nearest motorable point from the village is still a distant dream. Importantly enough, the electricity connection is still a promise waiting to be fulfilled. Now, contrast this with things that are being touted as a bouquet of strong enough initiatives, to better the lot of commoners in these distant pockets. The 'Jan Dhan Yojana', which has just been released, is an initiative to empower each citizen without any banking history until now, to have access to banking facilities. The concept of delivering ICT services, though not a new one exactly, is proving to be an instrument of significant all round change. With mobile telephony making huge rural inroads, the game changer is going to be mobile transfer of money. The next thing lined up is the cardless withdrawal of money from an ATM, wishing to mark its rural presence in big enough numbers in India. It is in this specific backdrop that a whole new paradigm of microgrids is taking shape for sure. Let us now take a close look at some key aspects of electrification status in India.

Rural Electrification Status in India

As on October 2013, there were 10 states which had already achieved the target of 100 per cent electrification in the rural areas. Nagaland was the least electrified state with 70.1 per cent of rural electrification. Table 1 presents the percentage of villages electrified in the country as per the report of Central Electricity Authority (CEA).

Table 1: Percentage of villages electrified in the country

State	% Electrification level
Andhra Pradesh	100
Arunachal Pradesh	75.5
Assam	96.1
Bihar	96.7
Chhattisgarh	97.1
Delhi	100
Goa	100
Gujarat	99.8
Haryana	100
Himachal Pradesh	99.9
Jammu and Kashmir	98.2
Jharkhand	89.2
Karnataka	100
Kerala	100
Madhya Pradesh	97.7
Maharashtra	99.9
Manipur	86.3
Meghalaya	86.3
Mizoram	93.5
Nagaland	70.1
Odisha	78.9
Punjab	100
Rajasthan	97.6
Sikkim	100
Tamil Nadu	100
Tripura	92.9
Uttar Pradesh	88.9
Uttaranchal	98.9
West Bengal	100



Some Intriguing Facts about Indian Villages

- Nearly 33 per cent of individuals out of the 1.2 billion, mostly located in the rural areas of India, do not have access to electricity.
- Around 93 per cent of urban households and a meager 55 per cent of rural households are availing electricity connection at present, according to 2011 census.
- Nearly 45 per cent of rural house-holds lack access to electricity in India.
- Nearly 18,000 villages were marked up as 'difficult to electrify' in 1999 due to their remoteness.
- About 95 per cent of the villages in the country are categorized as electrified as per the government ruling that a village is electrified if, a minimum of 10 per cent households are electrified together with the fact that if, public structures such as health centres and schools are also electrified.
- Providing electricity to all rural households via central electricity grid extension does not seem to be a viable solution.
- Villages which seem to be favourites for receiving the grid extension

facility still are clueless about when that is going to happen for sure.

In 1999, about 18,000 villages were classified as 'difficult to electrify,' suggesting that their remote location makes grid extension highly unlikely.

The Poor Demand for Energy

The low income levels present within the rural areas bring forth a relatively low energy demand. This is despite the fact that rural households are in need of electricity just like urban dwellers. Incidentally, it is often given to hear that rural households are willing to pay for electricity use. However, it is mainly concerned with small amount of electricity use. Such a use could be for running of two light bulbs besides charging a mobile phone. As per the Rockefeller Foundation, the average load for a rural household would be around 350 W corresponding to an assumed enhanced demand for three light bulbs, a TV, fan, and a few more appliances. Thus, for a rural village size ranging between 45–60 households, the peak load demand may still add up to just around 15–20 kW. Such a low demand for power makes it harder to recover the upfront investment, which is needed to extend the central grid or to install distributed generation technologies within the remote areas.

Key Technology Choices for Rural Electrification

The first obvious choice is that of extending the central grid to deprived villages. Second choice rests on the use of solar home systems and the third choice is that of building the microgrids. It makes sense to make a comparative evaluation of these three choices vis-à-vis the following few parameters:

- Generation source
- Site specifics
- Load and capacity losses
- Cost of generation for producers
- Electricity price for the consumers
- System reliability
- Requirements of operation and maintenance

Central Grid/Grid Extension

Successive governments in India have accorded high priority to extend the central grid to rural villages. However, it is equally true that it is not always a most cost-effective solution to extend the grid to remote villages. Table 2 presents the key attributes of the above-mentioned parameters as under:

Table 2: Key attributes of the parameters for extending the central grid to rural villages

Sources of Generation (as on 31.07.2014)	▪ Coal (149,178.39 MW) = 59.6% ▪ Hydropower (40,798.76 MW) = 16.3% ▪ Nuclear Energy (4,780 MW) = 1.9% ▪ Renewable Energy (31,692.11 MW) = 12.7%
Geographical Cost	▪ Matters the most as the distance from the grid increases especially for hilly areas with enhanced manual labour cost.
Loads	▪ Usually the demand for electricity far outweighs the ability of central grid to meet it, thus, leading to regular shortages during the times of peak electricity demand
Losses	▪ Major losses due to theft and illegal use of electricity from lines/tampering with meters, non-paying consumers, and non-billing/under-billing by distribution companies ▪ Country-wide losses touched 23.97% in 2010–2011 (as against just 6% transmission losses in China between 2009 and 2013) with Bihar showing the highest T&D losses of about 46.4% as per Greenpeace
Reliability of Power Supply	▪ Grid-based supply still associated with poor reliability ▪ Providing a limited supply of even six hours per day by the central grid, still not met in some states
Operation and Maintenance	▪ Maintenance of the grid power supply gets problematic due to power theft and system inefficiency
Price and Cost	▪ Real price is different from one state to the other and as per the consumer category ▪ Price for power for grid electricity consumers is around ₹3 per kWh (it does not show the real cost of power production and the cost of setting up the transmission lines for areas which happen to be far away from the source of generation) ▪ Estimated cost of generating, transmitting, and distributing electricity from a coal thermal power plant varies between ₹3.18/kWh to ₹231/kWh for villages separated by a distance of 5–25 km from the central grid ▪ In case of villages having 20 odd households and a peak load of 5 km (located at 5 km away from the grid), cost of electricity is ₹26 /kWh and an abnormally high cost of ₹95/kWh for grid distance of about 10 km

Solar Home Systems

Solar lighting is perhaps the most desirable end-use application across the developing world. The lighting products available in the marketplace usually range from a keychain light to solar torch and value added products like a hand-held light better known as solar lantern. Solar home system came into being for demand fulfilment of indoor lighting, running a fan, and television, etc. However, the major boost to the Solar home systems dissemination was provided by the World Bank who said that a SHS turns out to be the most cost effective option for the vexing issue of rural electrification. India alone has a field installation base of more than 500,000 solar home systems besides a still greater number of 700,000 solar lanterns. Key components of a solar home system generally include a few solar modules, battery storage system, charge controller, and loads such as tube lights/CFL/fan. Table 3 presents the key attributes of above parameters for a solar home system.

Defining a Microgrid

A microgrid in simple terms acts like an independent energy system, which is capable of offering grid backup or off-grid power. It basically refers to a single electric power subsystem which is linked to a small number of distributed generators. These can be powered by either renewable or non-renewable sources of energy together with different load clusters. A unique feature of a microgrid is that it is able to function independently of the central grid. In turn, this can help improve the power quality and reliability as well as allow the local community to exercise more control over their power network. Even once the microgrid is connected to a central grid network, the community can still have some level of control. Key components of a basic microgrid design configuration are as under:

- Decentralized generation sources (solar, wind, biomass, biogas, microhydro, diesel, etc.)
- Energy storage system (optional)
- Distribution system
- Communication and control system

Few key criteria for differentiating between different types of microgrids are the following:

- Whether it is connected to a central grid
- What type of generation sources are actually connected to the microgrid
- Table 4 presents the key attributes of above parameters for a Microgrid (see next page).

Table 3: Key attributes of parameters for a solar home system

Sources of Generation (as on 31.07.2014)	▪ Solar home system uses the freely flowing sunlight to convert it into useful electricity via solar cells
Reliability of Power Supply	▪ Batteries need to be maintained properly to enhance the field reliability ▪ Quality component selection and use is a must ▪ End-user must not connect the load which may be higher than the designated load
Price and Cost	▪ System cost is strongly dependent on the type and size of Solar Module/battery ▪ Per peak watt system installed cost may range anywhere between ₹ 50–95
System Capacity	▪ Capacity of a SHS is determined by the size of a solar module and battery rating too ▪ Typical capacity of a SHS is at a maximum of 100 W ▪ Ability to include income generating loads to the system is generally limited
Losses	▪ Losses from use of individual components add up ▪ Solar Home System usually has a lower efficiency mainly due to the use of low capacity system components such as modules
Geographical Cost	▪ Solar home system is capable of performing in most parts of India, soaked with enough sunshine ▪ No dependence on any kind of grid distribution network
Operation and Maintenance	▪ A SHS is generally easy to install and maintain ▪ Regular cleaning of solar modules together with topping of the battery with distilled water is to be ensured

Table 4: Key attributes of parameters for a microgrid

Sources of Generation	▪ Capable of accommodating a large spectrum of decentralized generation sources like solar, wind, biomass, micro-hydro, diesel, and solar-diesel and biomass-diesel hybrid power systems
Reliability of Power Supply	▪ Can suffer from some power quality and reliability issues accompanied with renewable energy sources in general and electricity distribution ▪ Common problems that can affect the distribution network mainly include voltage imbalance ▪ Energy storage system like batteries can help balance any short-term changes in energy supply and demand or for that matter a controllable diesel generation or connection to a larger grid network
Price and Cost	▪ Typical costs of generation vary between ₹ 23–33 per kWh much in accordance with the type of generation used in the microgrid ▪ Average monthly payments of around ₹ 100–200 per month ▪ Standalone microgrids turning out to be competitive with grid extension at distances exceeding 17 km ▪ In totality, DG is becoming an increasingly more cost effective option at increasing distances
System Capacity	▪ These may generally range between a few kW to a few hundred kW or even more
Losses	▪ Reduces the losses due to transmission and distribution and offers a viable medium of serving the remotest of areas ▪ Saves on the time otherwise needed for putting up a high voltage wiring system
Geographical Cost	▪ Solar power and biomass power offer the facility of widespread use unlike hydropower which is location specific
Operation and Maintenance	▪ Microhydro generation plant capable of running for about 50 years with bare minimum maintenance requirements ▪ Solar PV system also easy to run and maintain ▪ Biomass gasification based power generation system prone to residual matter deposit problem in its engine also implying a higher level of engine maintenance

The Possible Microgrid Solution(s)

Renewable energy technologies like solar, wind, and biomass have showcased their effectiveness to bring glow amongst the rural folks since many years now. As such a positive approach to tackling the challenge of rural electrification is to enhance the scope of decentralized energy generation via the use of microgrids. Simply put, a microgrid refers to a smaller scale electric grid combined with a local generation source. Prior to defining a microgrid in simple terms, it may be useful to highlight its potential as under:

- Enhances the magnitude of renewable energy sources making positive contribution to power needs
- Mixes renewables with other available power sources
- Delivers power in places devoid of any grid power connection
- Makes available, more reliable power in places served by grid
- Importantly, it leads to an enhanced stability and reliability of a power grid

As of now, the microgrids have reaped success mainly at the project level. The daunting challenge is to replicate them on a larger scale, say, in all those villages where it is considered as the best possible option for rural electrification. However, the underlying rationale to their large-scale penetration lies in the microgrid projects being technically reliable, financially feasible, and socially sustainable. Microgrids in terms of their technical attributes are running smoothly. To meet the financing challenges, it may be prudent to take recourse to the following few steps:

- Adopt a subsidy model that may scale back existing upfront capital subsidies and complement them with performance-based subsidies
- Ensure an increased access to capital by streamlining subsidy approval and payment process and drawing on other potential funding sources
- Corporate Social Responsibility (CSR) funds could well be diverted for the purpose
- Work towards the improvement of public–private partnerships and project quality deliverables via better franchisee arrangements, etc.

- Participation of local communities seems to be absolutely necessary for microgrid development and implementation
- Commission feasibility and demand studies during association with the community representatives
- The microgrid developers need to encourage a cooperative model in communities endowed with high levels of human capital and ownership over the renewable energy resources
- The not-for-profit entities including the private bodies act as facilitators to the rural microgrid cooperatives
- Community members should be roped in for collection of small frequent payments, etc.
- Capacity building initiatives in terms of training the local technicians to run and maintain the microgrid should be taken by the producers

The percentage of rural households with access to electricity moved up from 44 per cent to 55 per cent between 2001 and 2011, i.e., the two census reference years. This was mainly possible due to the efforts in extending the grid.

Diverse Dimensions of a Microgrid

There are several divergent aspects present within the Asia-Pacific region for instance. These mainly include demographic factors, variable economic and infrastructural levels along with different levels of power grid development, etc. Consequently, the demand for microgrids also differs from one market to another, in this region. It is also because of this fact that each country is at a different level of resource development. Currently, renewable energy based capacity is witnessing an upward trend along with a fast growing electricity consumption. Thus, a fast emerging demand for microgrid projects is foreseen, both for electrification purposes as well as technology demonstration-cum-experimentation value. Currently, developed countries located with the Asia-Pacific region are gathering field observation data from pilot projects and commercial installations too. The underlying objective is to get a practical feel of the technology preferences, business models alongside the financial models.

The Challenges Beneath

Several types of challenges are seen to exist in the well intentioned path of microgrid development in the Asia-Pacific region. Take for example the challenging issue of suitable management of existing power grids and the maintenance of more efficient balance between load and generation on the grid. The developed countries of the Asia-Pacific segment are encouraging the use of community based and commercial/industrial microgrid developments. Selective few, field demonstration projects delving on integration of renewable energy resources are currently being tested and developed. Pivotal objective is to make available a range of applications to an end-user. South Korea and Japan especially are saddled with a clear objective to export microgrid business models and systems to be followed up by occupying a good share of the global supply chain opportunities across the forward-looking international markets. Let us now try to compare the situation in the developing countries within the Asia-Pacific region. These countries are confronted with more pressing issues like the following few concerning the power supply:

- Low level of electrification
- Underdeveloped power grid infrastructure
- Lack of capital to underwrite new technologies so as to advance the power grid services
- Indeed both the governments and utilities are facing a daunting task of devising efficient means to supply the much needed power to rural villages and remote islands on a daily basis

Expected Deliverables of a Microgrid System

Microgrids have a striking impact on achieving increased dependence on different forms of distributed generation, advanced energy storage, demand response, etc. The microgrids seek a well-coordinated operation of the power storage system besides renewable distributed energy generation. The other allied requirements are maintenance of power grid supply besides demand imbalances as well as robust RDEG controls and enabling technologies. There is a unanimous view that the microgrids ought to be a decisive goal for providing electricity and securing energy efficiency.

Market Forecasts

As per the latest available market reports, several important countries in the Asia-Pacific region like China, Japan, Korea, Australia, Malaysia, Singapore, Indonesia, Philippines, and importantly, India are expected to record steady market growth in both the grid-tied and remote microgrid segments. These are being seen as vehicles of change to achieve enhanced energy access, thus, eventually leading to generation of new forms of economic development. Figure 1 shows the annual grid-tied and remote microgrid capacity by select country within the Asia-Pacific region during the period 2013–2023. In sum total terms, perhaps the most attractive microgrid market in the Asia-Pacific region are remote microgrids. These run autonomously or have yet to be connected to the larger grid. The historical trend has been to make use of diesel-based power generation but the newer perspective is certainly in favour of renewables based remote microgrids.

Currently India, Indonesia, and the Philippines are counted as the market leaders for remote microgrids in Asia-Pacific, in view of their strong commitment for extending the benefits of electricity far and wide. Of special mention is Australia due to its unique need for power supplies to off-grid or isolated mining sites. The annual grid tied and remote microgrid capacity in the nine select countries as per Navigant consulting is expected to grow from 37 MW in 2013 to around 600 MW by 2023 at a compounded annual growth rate of 32.1 per cent.

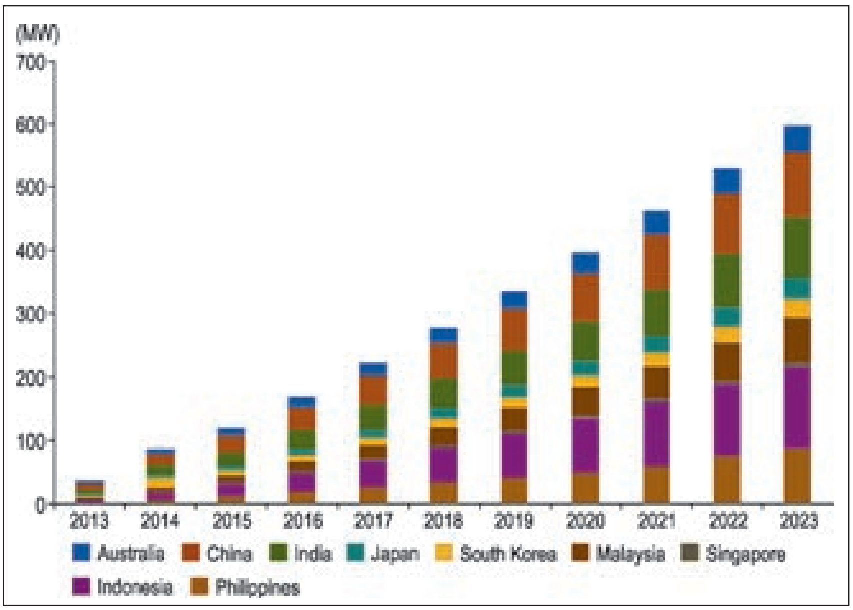
Selective Few Microgrid Projects

There are still a large number of remote villages in the country awaiting a grid power connection. With due realization to this fact, several pilot scale projects have been put in place in a smooth manner so far. Of special mention are the following few case specific examples:

Currently India, Indonesia, and the Philippines are counted as the market leaders for remote microgrids in Asia-Pacific, in view of their strong commitment for extending the benefits of electricity far and wide. Of special mention is Australia due to its unique need for power supplies to off-grid or isolated mining sites.

Sagar Islands

There are many isolated decentralized generation systems present in the country. Till the onset of 1996, major part of the island used to get power for just a few hours every evening via a diesel generator of 300 kW. 'Sagar Islands located in the eastern region of India, i.e., West Bengal is counted as a successful example of microgrid power system implementation. A beginning of sorts was made by setting up a 26 kWp solar PV power project. This specific project has been jointly funded by the Ministry of New and Renewable Energy (MNRE), Indo-Canadian Environment Facility (ICEF), and West Bengal Renewable Energy Development Agency (WBREDA). As per the available data, power demand in the Sagar Island is currently being met from a cumulative solar power capacity of 300 kW and by a diesel generator of 400 kW. In all, about 1,500 consumers are benefitting



Annual Grid-tied and Remote Microgrid Capacity by Select Country, Asia Pacific: 2013–2023 from this innovative microgrid solution. However, a sizable number of potential customers are aspiring to be a part of this microgrid solution. As a remedial measure, a wind diesel hybrid power system of around 500 kW was operationalized. The system provides six hours of electricity every evening for the domestic customers up to a maximum usage of 30 kWh per month. A 3-tier tariff structure has been put in place on an actual electricity consumption basis vis-à-vis the domestic, commercial and industrial type of customer segments. These tariff rates vary between ₹5–6 for such customer categories.

GramOorja

This organization came into being in 2008 and aims to achieve the objective of rural power solutions. It utilizes the rural mini grids based on renewable energy sources like solar, small wind, biogas, and biomass for off-grid villages. Darewadi, located in north of Pune, Maharashtra houses a solar-powered microgrid. The grid power connection is barely a kilometre away from this village mainly on account of its difficult topographical terrain amidst hilly surroundings. Here, a solar power system of 10 kW is serving the end-use requirement of about 40 households under the purview of corporate social responsibility mandate with Bosch Solar energy. A unique feature of this system is that around 70 per cent of the total average energy generation has been set aside for running of selective few productive activities like a flour mill and a pump. The capital upfront costs for this solar microgrid project were met by Bosch but the end-users were charged at the rate of ₹20 per kWh. This is mainly to take care of the battery replacement cost at the end of five years. Thus, the villagers make a monthly contribution ranging between ₹120–150 on the electricity usage. A local committee facilitated by GramOorja is the key decision maker with regard to this microgrid system.

Mera Gao Power

Akin to the GramOorja is another small micro enterprise known as Mera Gao Power. Presently, it is meeting the electricity needs of a small number of villages within Uttar Pradesh. A well standardized model is at work to firm up the timing and daily hours of use of a specific microgrid system. The system design configuration takes just around a day to install in a village or a hamlet. Power is being provided to the customers for the lighting of a few LED bulbs aside of a cell phone charging facility. The electricity from microgrids costing about ₹55,000 is available for seven hours per day and is maintained by a local technician trained specifically for the purpose by Mera Gao Power. As for the payment collection on a weekly basis in advance, a local women's group is actively involved.

A well-standardized model is at work to firm up the timing and daily hours of use of a specific microgrid system. The system design configuration takes just around a day to install in a village or a hamlet.

It is now pertinent to summarize the most important features of the above

Table 5: Most important features of the three microgrid models

Parameter	Sagar Island	GramOorja	Mera Gao Power
Village Size	Total of 160,000 inhabitants, consumer base of about 1,500	Around 40 households	Around 35 households per village
System Size	Solar PV Unit: 300 kWp Wind Unit: 500 Kw Diesel Unit: 500 Kw	Solar PV Unit: 10 kWp	Solar PV Unit: 600 Wp
Source (s) of Generation	PV/Wind/Diesel	PV	PV
Average per day availability of electricity	7 hours	5–6 hours per night for household use and limited to 30 kWh/month	Round the clock availability with implicit limits set on utilization
Recovery of the capital cost	Receipt of joint funding from MNRE/ICEF/WBREDA	Set up under the Corporate Social Responsibility Funds of Bosch	Recoverable from the village payments in about 3 years
Monthly tariff payable	₹5/kWh (residential) ₹5.5/kWh (commercial) ₹6/kWh (Industrial)	₹20/kWh with ₹90 per month as a lower bound fixed cost	Flat connection fees of ₹25 and ₹25 per week for the services rendered

three microgrid models from several key considerations in Table 5.

Key Routes of Microgrid Project Financing in India

Several financial and fiscal incentives have been made available from time to time under the ambit of various programmes/schemes of the government to push forward the development of microgrids in the country. Following is the point specific mention of the key financing mechanisms for microgrids:

- Capital subsidies have been extended to those desirous of developing the microgrid systems by the government.
- Such subsidies have been made available under the purview of Ministry of Power and Ministry of New and Renewable Energy via a wide array of government initiatives targeted at rural electrification.
- Ministry of Power under its flagship rural electrification programme has subsidized 90 per cent of the capital costs for decentralized and distributed generation in areas with a prior determined view of conventional power extension being either uneconomical or unfeasible.
- The Rural Electrification Corporation (REC) covers the balance 10 per cent of the capital costs in the form of a soft loan at an interest rate of 5 per cent.
- Akin to Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY), the Rural Village Electrification (RVE) programme offers a 90 per cent capital subsidy for the projects that offer basic lighting electrification services to villages with a population size of more than 300 inhabitants not eligible for the RGGVY.
- The government is presently running a programme which is a combination of 30 per cent subsidy and a loan with an interest rate of 5 per cent to off-grid solar projects.
- The Ministry of New and Renewable Energy provides capital subsidy ranging from 50 per cent to 90 per cent of the project cost. Case specific qualifying projects include for example off-grid wind and wind-solar hybrid systems.
- The Ministry of New and Renewable Energy (MNRE) is currently encouraging the development of microgrid projects on a Build, Operate, Manage and Transfer (BOMT) basis. Private firms are especially motivated to enter the market as microgrid developers and managers for a short period of time, say up to five years. Upon the expiry of this period, the project is transferred to a suitable government agency in case the central grid reaches the microgrid location in the interim period.
- MNRE currently focuses its support on microgrid projects that fit a 'Build, Operate, Manage and Transfer' (BOMT) model. BOMT and prevailing subsidies encourage private firms to enter the market as microgrid

> HOMER stands for hybrid optimization of multiple energy sources. It basically steers the complexities of developing economical and reliable microgrids that are a sound blend of traditionally generated and renewable power together with storage and effective load management.

developers and managers for a short period of time, up to five years. After five years, or if the central grid reaches the microgrid during the interim, the project is transferred to the appropriate government agency.

Microgrid (ing) Path Forward

The free flowing availability of sunshine together with breeze filled surroundings is the precursor to laying down of successful installations of microgrids. Use of diesel for several high value added applications in telecommunication, refrigeration, and battery charging for oil- and gas-based pipelines is expected to maintain its lead for some time in the foreseeable future too. However, as solar systems become more and more reliable at a diminishing cost, micro gridding with solar in far enhanced numbers may become a close reality. Simultaneously, agents of change who have to take microgrid experiences forward so far have had to emerge at the policy, planning, regulatory, and programme implementation levels in an easy to replicate manner. The onus lies on the full spectrum of stakeholders to think of quite innovative microgrid projects with a sound technology base, smoothly implementable operation, and maintenance mechanism. It is no less important to disseminate the key outcome of microgrid projects irrespective of their actual gains. The underlying rationale is to develop a clear-cut understanding of the significant issues and challenges of microgrid system functioning from all possible considerations. Generation mix based projects may hold a special significance for reasons more than one. It is quite important to highlight the use of some simulation software like HOMER. HOMER stands for hybrid optimization of multiple energy sources. It basically steers the complexities of developing economical and reliable microgrids that are a sound blend of traditionally generated and renewable power together with storage and effective load management.

In totality, energy providers of all types across the world today are exploring the use of microgrids to incorporate renewable power resources, reduce the greenhouse gas emissions besides achieving the energy security and associated independence. As of now, the remote island and off-grid systems sector happens to be the largest microgrid segment worldwide. It is equally true that utilities are more than keen to exploit the grid tied microgrids as a service offering for the well profiled commercial and industrial range of customers. India seems to be on the brink of a microgrid revolution of sorts while considering a dire enough need for providing energy access to the farthest of inhabited locations. After all, mobile telephony has given a speaking closeness to everyone today thus removing the geographical divides. What better—a solar microgrid system based solution to empower everyone in no uncertain terms. EF

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San Francisco
Intersolar Conference 2014

The recently held San Francisco Intersolar Conference was even more jammed than usual, with three floors holding 587 exhibitors. The booths were staffed by managers and engineers, resulting in intelligent answers to journalists' questions.

Industry Sector Representation

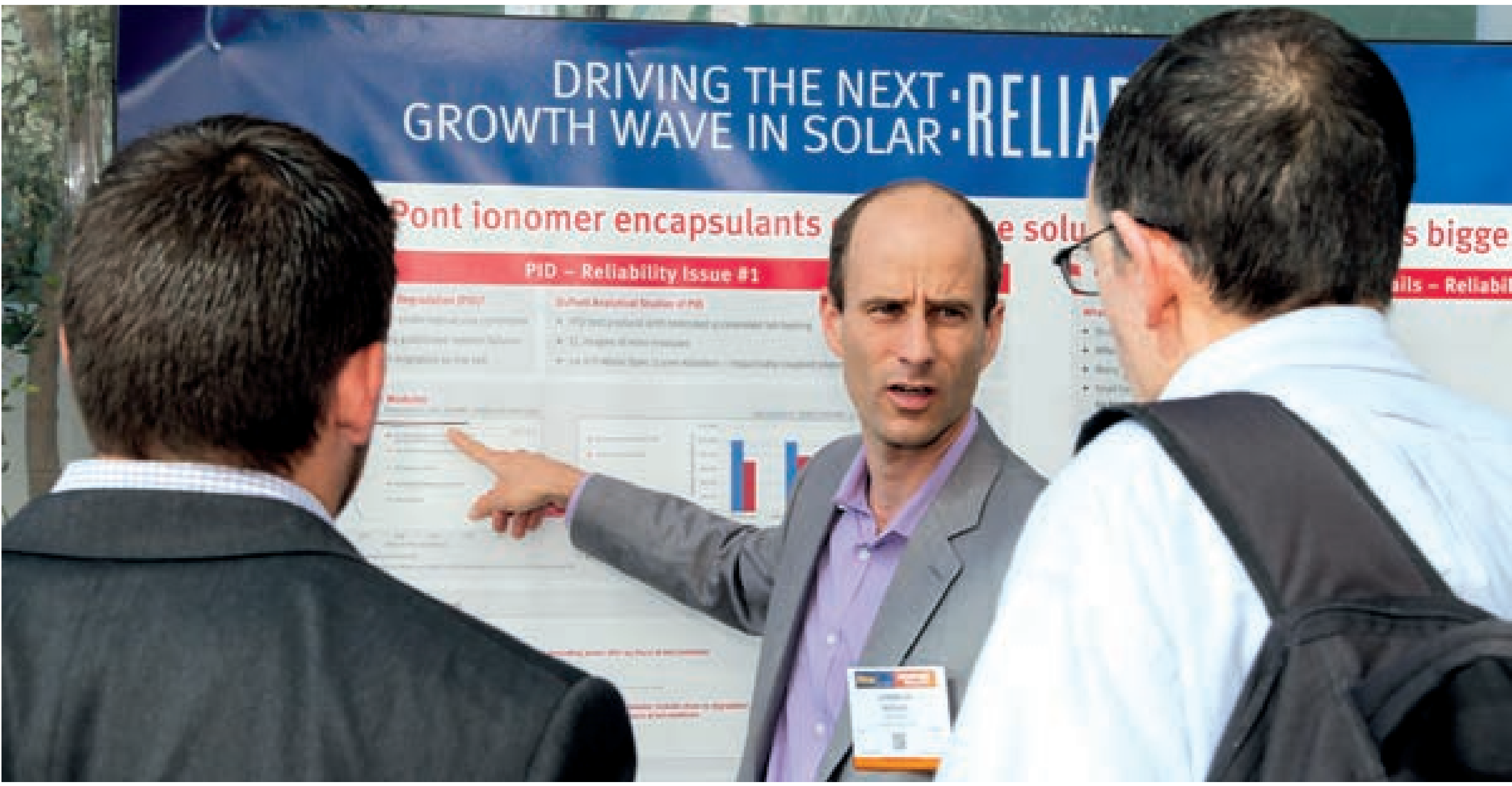
While a number of major manufacturers were present, along with countless subcontractors and service providers, no large solar farm developers exhibited or delivered speeches. This contrasts with previous Intersolar events, when large solar developers either exhibited or were prominent in receptions and product demonstrations. This could be because of the recent major turnover among solar developers, due to entitlement and transmission challenges in the American Southwest. The solar trade group, SEIA, now features programmes almost exclusively focused on much smaller distributed projects, which are less risky.

This change in focus does not bode well for the rapidity required if American grid power is going to seriously address global warming via a transition to renewable energy. In California, only 6 per cent of electricity demand comes from houses, and 23 per cent of total energy use (including fossil HVAC). This means that even with the lofty goal of 50 per cent residential solar penetration, natural gas powered electricity will remain the primary source of electricity should grid scale plants continue to progress slowly.

Key Technical Innovations

Among several technical innovations displayed at the conference, the following wer the key features:

- Solar panels can now be built by robots.



- There has been a breakthrough in solar field foundations via the use of diesel-powered portable drivers that sink panel array box beam support columns deep into the soil. An acre or more of columns can be sunk in a day. Use of costly and water intensive concrete piers is avoided.
- Better engineering and permitting software is being developed, shortening approval processes and streamlining documentation.
- Storage technologies, now mostly batteries, are advancing rapidly in terms of cost savings and battery life. Lead acid, lithium, and vanadium are the key technologies. All have advantages and disadvantages, and the market should sort out the winner before long.

Solar Panel Cost Projections

There was disagreement among exhibitors as to whether hard costs of solar panels can be expected to rise or fall in the next five years. A German solar executive said that he believed that prices were currently in a trough, and that the low prices of 2011–13 were a result of overproduction and heavy discounting. Now that surplus product and manufacturing equipment had been absorbed, he predicted slowly rising prices.

Two presenters in a conference room had an opposite view. Both were promoting startup thin panel firms, and claimed hard costs of \$0.24 per watt for one, based on simplified and advanced substrate design, and another claimed \$0.28 per watt if a large enough (300 MW per year) thin film manufacturing plant could be built per his specifications. Industry costs are currently in the range of \$0.45–0.50. Both were solar industry veterans, but it is difficult to evaluate their claims at this point.

Future unknowns also include manufacturer claims of 22 per cent efficiency in the next generation of panels, but that number has not been verified in real world installations. Should it be correct, absent major manufacturing unit cost increases, cost savings would be huge.

Regardless, the major unknown cost factor in California for either distributed or utility scale solar is the soft cost of entitlements. Germany has fould out its solution and delivered distributed solar for half the cost of Americans, using the same commodity panels.

Utility scale solar delays and unanticipated legal and environmental costs have reduced investor interest in California, a problem that remains unaddressed. A gas company can rapidly obtain permits to send explosive materials into the ground to free natural gas. Gas power plant construction permitting is also routine, since all elements are commodities. In contrast, solar farms experience delays lasting for several years and beyond, often leading to project abandonment.

Quality Issues

DuPont engineers hosted a rooftop event at the Intercontinental in order to address quality issues for PV solar panels. There appear to be two main challenges: Vendors cut manufacturing costs during the dumping period of 2011–2013, resulting in substandard units. The second challenge is existing sealers failing to sufficiently account for expansion or contraction under high temperature gradients. Water would penetrate the glazing, damaging the PV face.

These problems are well on the way to being solved, as the industry is sharing information, and making sure that warranties are honoured and design flaws addressed. EF

Contact: For questions about specific companies, along with company contact information, the reader can email Mike Roddy at mike.greenframe@gmail.com

Acknowledge possibility of using microgrid-based technologies

According to a study, microgrids are the fastest growing sector of new energy access, with roughly half of all the new microgrids in India. Ms Sapna Gopal for *Energy Future* talks to **Mr Sanjoy Sanyal**, Country Director, New Ventures, elaborates on the growing relevance of microgrids in India.

In February this year, researchers from Carnegie Mellon University and the Renewable and Appropriate Energy Laboratory of the University of California, Berkeley, along with the UN Foundation's Energy Access Practitioner Network, collaborated on '*Microgrids for Rural Electrification: A critical review of best practices based on seven case studies*,' which was released by the United Nations Foundation. The study, which evaluated the contribution of microgrids to electrification in developing countries, states, 'microgrids, distributed systems of local energy generation, transmission and use, are today technologically and operationally ready to provide communities with electricity services, particularly in rural and peri-urban areas of less developed countries.'

According to Prof. Daniel M Kammen who led the research, microgrids are the fastest growing sector of new energy access, with roughly half of all the new microgrids in India. Also, rural microgrids are the most rapidly evolving, with new technology (meters, sensors, low-cost solar panels) and new opportunities to train key developments.

Undoubtedly, microgrids have positively changed the lives of people in villages such as Sharif, Siwan, West Champaran (districts of Bihar) and in the Gonda, Sitapur, Hardoi, and Unnao districts of Uttar Pradesh, as per field studies conducted by New Ventures, a company which addresses the key barriers to 'green' entrepreneurial growth by building in-country support networks for environmental enterprises and increasing their access to finance. **Sanjoy Sanyal,** Country Director, New Ventures, elaborates on the growing relevance of microgrids in India.

Microgrids have been successful in lighting up cities and towns across the globe. In such a scenario, what is their potential?

Microgrids can work in two ways; one, provide highly reliable supplies to closely clustered customers in likely urban customers and two, electrify off-grid likely densely populated rural customers.

It is believed that there has been a big mindset shift among regulators and utilities in favour of microgrids. Would you agree?

No. Most distribution utilities' are large bureaucracies and like most strongly entrenched incumbents, they struggle in the face of disruptive technologies. I am not aware of the big mind shift.

With regard to policy, what is the support that this sector requires? Also, do you think the current status is viable enough?

In the context of developing countries like India and Cambodia where there are significant energy access challenges, the most important policy angle is to acknowledge the possibility of using microgrid based clean energy technologies as a viable option to provide electricity. At this point to most planners, that is not even an option that is on the table.

Once that option is acknowledged, it is easier to have private sector franchisee arrangements. Cambodia for instance, already has a few hundred distribution and generation licensees each effectively running their microgrid. Unfortunately, many of them do not have the necessary financial strength or incentive to invest in viable clean energy generation. India already has a practice of distribution franchises. It can expand this practice to allow private sector players to both produce and distribute power within a microgrid. This would allow the country to make millions of people access electricity in a very quick time frame.

Over the years, what is the impact that microgrids have had, with regard to lighting villages and towns? Has it become more reliable than the grid?

It all depends on the business model. In general, private sector players are incentivized to provide reliable power because they have to collect money every week or every month. But, we must also remember that private sector companies can go bankrupt. Government funded projects, on the other hand, may not have enough operational efficiencies and plans built into the plans. Our experience is that committed private sector players offer reliable power when there is none, but the long term sustenance of their services depends on their ability to gather investment and scale their operations.

In terms of the business model of microgrids, how cost-effective is it? Does it garner enough profit so as to prompt people to invest in this?

Operationally, most microgrids seem to make enough money to be able to generate returns. There is also a breed of impact investors who are willing to invest for low and positive returns. The biggest obstacle for investment is the risk of 'what happens if the grid expands here'. This needs to be addressed with far more urgency.

Could you tell us a bit about the work that has been undertaken by your organization, with regard to microgrids?

We have helped facilitate investment deals into microgrids. In our latest deal, we have facilitated the support of Gham Power by the DOEN Foundation to set up a 35 kW solar microgrid to power 25 businesses and 83 households in three rural communities in Nepal. Mera Gaon Power with its solar microgrid model and Husk Power systems with its biomass based microgrid model have both benefitted from participating in our Investor Forum and from our advisory services.

We have published the New Ventures India Briefing Note on Microgrids targeted at investors, entrepreneurs and policy makers. Also, the Clean Energy Access Markets analysis identifying districts where microgrids can be operated.

Could you explain how communities in various countries have benefitted from the microgrid projects undertaken by your organization?

There is no doubt that quality of life improves. Also, there is increasing data that incomes rise, children study for longer hours (thus improving income earning potential in the future). But private sector entrepreneurship has its own benefits. People of different caste groups work together in a modern enterprise for the first time.

Women learn to handle machines. This is probably the first time modern technology and management has entered this community.

What are the future plans of the organization, with regard to microgrids? Which are the countries that you intend to tap?

We intend to work with more investors who want to invest in rural energy and water access projects in Asia and Africa. EF

SUSTAINAB
A Need for

Dr Aruna Sharma emphasizes on sustainability and green future, and optimum application of renewable energy resources the country possesses. Read on.

Energy has been amongst the key factors, directly affecting the future of an economy. The developmental status of a country depends on its energy efficiency in each and every sector of utilization—be it, industries, agriculture, commercial, or household.

In our country, energy crises vary from electricity shortages, low voltage situations, black outs, etc., to energy-nil areas that are still waiting for access to electricity. The so-called reason for the energy crisis faced in India is due to over-dependence on non-conventional energy resources and less use of renewable energy.

But if the situation will be viewed with a slightly different perspective, the very important fact unfolds that energy crisis faced today by every citizen is due to unsustainable production of electricity whether it be from renewable or non-renewable energy sources.

The latest example supporting this viewpoint is Uttarakhand that faced the worst natural calamity, worsened to high impact situation in the process of tapping renewable energy in the form of hydropower. The electricity which was generated here was renewable but not sustainable. The energy generated here from hydropower was based on creating large dams on the major rivers of this area, obstructing the natural flow of pristine river ecosystem. In the times, when this area was badly hit by natural calamity, the fact that came into light was that the electricity generation here was neither economically viable, nor ecologically sound nor socially responsible. Though here renewable energy has been harvested but in the process, the very delicate environmentally fragile ecosystem has been badly disrupted, the social lifestyle has been badly devastated and the economic viability of these structures is also questionable as crores of rupees have already being spent to create these mega structures and then they have been hopped over by nature to prove that how unsustainability cannot persist in nature. The very important fact that unfolds

LE ENERGY
Green Future

is that whatever be the source of energy, it has to be sustainable in environmental, economic, and social terms. Thus, sustainable energy is clean and local energy that is tapped in integration with traditional cultural setup, local terrain, available ecological conditions, and community participation.

In light of above mentioned fact, the only solution for today's energy crisis lies neither in harnessing renewable energy nor on tapping non-renewable sources, but on generation of sustainable energy. EF

Dr Aruna Sharma is a Scientific Officer with Rajasthan Pollution Control Board.

CURRENT R&D SOLAR

A Hybrid Forecasting Model with Parameter Optimization for Short-Term Load Forecasting of Microgrids

Applied Energy, Volume 129, September 2014, Pages 336–345

Nian Liu, Qingfeng Tang, Jianhua Zhang, Wei Fan, and Jie Liu

Short-term load forecasting is an important part in the energy management of microgrid. The forecasting errors directly affect the economic efficiency of operation. Compared to larger-scale power grid, microgrid is more difficult to realize the short-term load forecasting for its smaller capacity and higher randomness. A hybrid load forecasting model with parameter optimization is proposed for short-term load forecasting of microgrids, being composed of Empirical Mode Decomposition (EMD), Extended Kalman Filter (EKF), Extreme Learning Machine with Kernel (KELM), and Particle Swarm Optimization (PSO). Firstly, the time-series load data are decomposed into a number of Intrinsic Mode Function (IMF) components through EMD. Two typical different forecasting algorithms (EKF and KELM) are adopted to predict different kinds of IMF components. Particle Swarm Optimization (PSO) is used to optimize the parameters in the model. Considering the limited computation resources, an implementation mode based on off-line parameter optimization, period parameters updating, and on-line load forecasting is proposed. Finally, four typical microgrids with different users and capacities are used to test the accuracy and efficiency of the forecasting model.

An Optimization Model for Regional Microgrid System Management Based on Hybrid Inexact Stochastic-Fuzzy Chance-Constrained Programming

International Journal of Electrical Power & Energy Systems, Volume 64, January 2015, Pages 1025–1039

L Ji, D X Niu, M Xu, and G H Huang

Microgrid system management considering air pollutant control and carbon dioxide (CO_2) mitigation is a challenging task, since many system parameters such as electric demand, resource availability, system cost as well as their interrelationships may appear uncertain. To reflect these uncertainties, effective inexact system-analysis methods are desired. In this study, a hybrid Inexact Stochastic-Fuzzy Chance-Constrained Programming (ITSFCCP) was developed for microgrid system planning, and Interval-Parameter Programming (Ipp), Two-Stage Stochastic Programming (TSP), and Fuzzy Credibility Constrained Programming (FCCP) methods were integrated into a general framework to manage pollutants and CO_2 emissions under uncertainties presented as interval values, fuzzy possibilistic, and stochastic probabilities. Moreover, FCCP allowed satisfaction of system constraints at specified confidence level, leading to model solutions with the lowest system cost under acceptable risk magnitudes. The developed model was applied to a case of microgrid system over a 24-h optimization horizon with a real time and dynamic air pollutant control, and total amount control for CO_2 emission. Optimal generation dispatch strategies were derived under different assumptions for risk preferences and emission reduction goals. The obtained results indicated that stable intervals for the objective function and decision variables could be generated, which were useful for helping decision-makers identify the desired electric power generation patterns, and CO_2 emission reduction under complex uncertainties, and gain in-depth insights into the trade-offs between system economy and reliability.

Off-Grid Solar PV Power for Humanitarian Action: From Emergency Communications to Refugee Camp Microgrids

Procedia Engineering, Volume 78, 2014, Pages 229–235

Joseph Franceschi, Jaron Rothkop, and Gabriel Miller

The need for new innovative technologies to support humanitarian action is evident today. Efficient and economic technologies properly deployed and integrated should mitigate some of the potential negative social effects of poor refugee camp infrastructure engineering. The body of the paper identifies off-grid solar Photovoltaic (PV) and solar PV hybrid packaged systems that are applicable to emergency relief activities, refugee camp activities, and microgrid development. The paper's concentration on off-grid power, the description of these engineered systems by humanitarian activity and the identification of the different engineered packaged solutions is aimed at stimulating a discussion to help scale more appropriate technologies for humanitarian action. The paper concludes with a discussion of present and future private sector business strategies to support scalability of this new and growing market.

Towards Understanding the Benefits and Challenges of Smart/Microgrid for Electricity Supply System in Nigeria

Renewable and Sustainable Energy Reviews, Volume 38, October 2014, Pages 1003–1014
Joseph O Dada

The poor state of electricity supply system in Nigeria is threatening the welfare and security of life and properties of millions of individuals with adverse economic consequences for the country. The inadequacy of the national grid, especially the inability of the electricity generation capacity to match increasing demand in the country has led to increasing agitation for increased penetration of renewable energy sources (RESs) into the electricity supply mix. While great attention has been focused on the potential of RESs for electricity generation in the country, little or no attention has been given to the application of Smart/Microgrid (SM-G) technologies to the ageing Nigeria grid infrastructures and electrification of the rural areas. The aim of this paper is to bring into focus the benefits and challenges of enabling SM-G in the electricity supply system in Nigeria. SM-G will bring benefits to the electricity stakeholders in form of improvements in reliability, efficiency, economics, environment, security, and safety. The paper gives an overview and reviews the current state of the electricity supply system in the country. It discusses the SM-G concepts and associated technologies, and highlights how they can help address the electricity problems in the country. The challenges of applying these concepts in Nigeria context are also discussed. Enabling SM-G in the country will not only lead to improvement in the quality, efficiency, and reliability of the electricity grid, but also promote the provision of electricity supply to the remote rural areas using RESs.

An Analytical Literature Review of the Available Techniques for the Protection of Microgrids

International Journal of Electrical Power & Energy Systems, Volume 58, June 2014, Pages 300–306
Sohrab Mirsaeidi, Dalila Mat Said, Mohd. Wazir Mustafa, Mohd. Hafiz Habibuddin, and Kimia Ghaffari

During the last decade, besides the rapid increase in the penetration level of Distributed Generation (DG) units of microgrids, the connection of microgrids as a developed technology to the existing distribution networks has also attracted much attention. One of the major challenges associated with the protection of microgrids is to devise a proper protection strategy that is effective in the grid-connected as well as the island mode of operation. In order to deal with the challenge, many researchers have recently proposed various techniques. The purpose of the current study is to provide a comprehensive review of the available protection techniques that are applied to address microgrid protection issues in both grid-connected and islandmode. The most up to date relevant options are described and categorized into specific clusters. A comparative analysis is carried out in which the advantages and disadvantages to each technique are assessed. Lastly, after the appraisement of the existing protection techniques, some conclusions and suggestions are put forward for the protection of microgrids in the future.

Progress and Problems in Microgrid Protection Schemes

Renewable and Sustainable Energy Reviews, Volume 37, September 2014, Pages 834–839
Sohrab Mirsaeidi, Dalila Mat Said, Mohd. Wazir Mustafa, Mohd. Hafiz Habibuddin, and Kimia Ghaffari

Globally, gradual depletion of fossil fuel resources, poor energy efficiency, and environmental pollution are among the main problems faced in the conventional power system. This leads to a new trend of generating power locally by using Distributed Energy Resources (DERs) at distribution voltage level. The concept of microgrid has appeared as an attractive alternative for integration of DERs in the distribution networks which has numerous advantages in terms of reliability and power quality. Despite the advantages, several challenges are still hindering the development of microgrids. One of the challenges is microgrid protection, and to resolve this, researchers have been working to develop different protection schemes. The objective of this study is to review previous research works on the existing protection strategies deployed in addressing microgrid protection issues in both grid-connected and island mode of operation.

Stochastic Scenario-Based Model and Investigating Size of Battery Energy Storage and Thermal Energy Storage for Microgrid

International Journal of Electrical Power and Energy Systems, Volume 61, October 2014, Pages 531–546
Sirus Mohammadi and Ali Mohammadi

Energy Storage Systems (ESS) are designed to accumulate energy when production exceeds demand and to make it available at the user's request. They can help match energy supply and demand, exploit the variable production of renewable energy sources (e.g., solar and wind), increase the overall efficiency of the energy system and reduce CO_2 emissions. This paper presents a unit commitment formulation for microgrid that includes a significant number of grid parallel PEM-Fuel Cell Power Plants (PEM-FCPPs) with ramping rate and minimum up and down time constraints. The aim of this problem is to determine the optimum size of energy storage devices like hydrogen, thermal energy, and battery energy storages in order to schedule the committed units' output power while satisfying practical constraints and electrical/thermal load demand over one day with 15 minutes time step. In order to best use multiple PEM-FCPPs, hydrogen storage management is carried out. Also, since the electrical and heat load demand are not synchronized, it could be useful to store the extra heat of PEM-FCPPs in the peak electrical load in order to satisfy delayed heat demands. Due to uncertain nature of electrical/thermal load, photovoltaic, and wind turbine output power and market price, a two-stage scenario-based stochastic programming model has been designed. In this, the first stage prescribes the here-and-now variables and the second stage determines the optima value of wait-and-see variables under cost minimization. Quantitative results show the usefulness and viability of the suggested approach.

An Inexact Two-Stage Stochastic Robust Programming for Residential Microgrid Management-Based on Random Demand

Energy, Volume 67, 1 April 2014, Pages 186–199
L Ji, D X Niu and G H Huang

In this paper, a stochastic robust optimization problem of residential microgrid energy management is presented. Combined Cooling, Heating, And Electricity technology (CCHE) is introduced to satisfy various energy demands. Two-stage programming is utilized to find the optimal installed capacity investment and operation control of CCHP (combined cooling heating and power). Moreover, interval programming and robust stochastic optimization methods are exploited to gain interval robust solutions under different robustness levels which are feasible for uncertain data. The obtained results can help microgrid managers minimize the investment and operation cost with lower system failure risk when facing fluctuant energy market and uncertain technology parameters. The different robustness levels reflect the risk preference of microgrid manager. The proposed approach is applied to residential area energy management in North China. Detailed computational results under different robustness level are presented and analysed for providing investment decision and operation strategies.

Power Management of Hybrid Micro-Grid System by a Generic Centralized Supervisory Control Scheme

Sustainable Energy Technologies and Assessments, Volume 8, December 2014, Pages 57–65
Mir Nahidul Ambia, Ahmed Al-Durra, Cedric Caruana, and S M Muyeen

This paper presents a generic centralized supervisory control scheme for the power management of multiple power converters based hybrid microgrid system. The system consists of wind generators, photovoltaic system, multiple parallel connected power converters, utility grid, AC and DC loads. Power management of the microgrid is performed under two cases: grid mode and local mode. Central Supervisory Unit (CSU) generates command signal to ensure the power management during the two modes. In local mode, the DC loads in the AC–DC hybrid system can be controlled. In the case of grid mode operation, power flow between the utility grid and microgrid is controlled. A novel feature of this paper is the incorporation of the multiple power converters. The generated command signal from the CSU can also control the operation of the multiple power converters in both grid and local modes. An additional feature is the incorporation of sodium sulphur battery energy storage system (NAS BESS) which is used to smooth the output power fluctuation of the wind farm. The effectiveness of the control scheme is also verified using real time load pattern. The simulation is performed in PSCAD/EMTDC. EF

Enabling Energy Efficiency in the **farm-to-fork** model

Cold Chain Automation Technology by Danfoss India

Danfoss India, which offers energy efficient solutions in different parts of the supply chain from farm-to-fork is keen on reaching out to all the stakeholders. With the recent announcement by Union Cabinet Minister for Food Processing Industries Harsimrat Kaur Badal that food wastage will be reduced by 50 per cent in next two years, focus has shifted to the farm-to-fork supply chain where there is a dire need to mitigate post-harvest losses. Danfoss India takes care of the need for sustainable cold chains and skill development in this industry. Hence, the company has a portfolio of products in its *Farm-to-Fork* mission. These products aim at energy efficiency like FC 103 Drive refrigeration, FC 360 automation drive, and other RC products.

The VLT® Automation Drive FC 360 is a dedicated industry drive that provides precise and efficient motor control in a wide range of industrial applications. Due to the fact that all Danfoss frequency converters follow the standard design and operating principle, existing owners and users of VLT® drives will feel instantly at home when operating the VLT® Automation Drive FC 360.

Its built-in features help owners save space in installations, time in setup, and effort in daily maintenance. The result is a powerful and versatile solution that increases process efficiency and quality in a cost efficient package. Featuring a basic yet comprehensive feature set, the drive provides precise and energy efficient motor control. Available in 5 frame sizes, the VLT® Automation Drive

FC 360 can control electrical motors from 0.37–75 kW.

Designed to work in harsh and humid environments, the drive provides reliable operation in industries such as textile, pharma and chemical, plastic and rubber, metal work, material handling, food and beverage, and building materials.

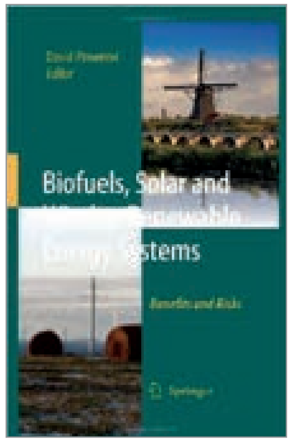
The drive enables precise and efficient motor control of a wide range of industrial applications such as extruders, winders, conveyors, drawing benches, ring frame, texturizing, air compressors, mixer coolers, cranes, escalators, pumps and fans. The efficient cooling concept ensures there is no forced air over the printed circuit board, which improves reliability.

Also, a removable fan makes it possible to clean the inside of the drive quickly and easily, thereby reducing the risk of downtime. Special coated PPCBs used in the drive are standard to handle aggressive environment & reliable performance.

FC 360 also reduces initial costs and effort with a wide range of built-in features that simplify installation and commissioning, including an EMC filter, built-in brake chopper up to 22 KW and a user-friendly numeric display. As standard Danfoss VLTs are designed with built in DC harmonic filters, it eliminates the need for installing external AC line chokes.' EF

Contact: Danfoss India, Leela Satyanarayan, E-mail: LSatya@danfoss.com, and Genesis Burson-Marsteller, Manasa Kumar, E-mail: manasa.kumar@bm.com

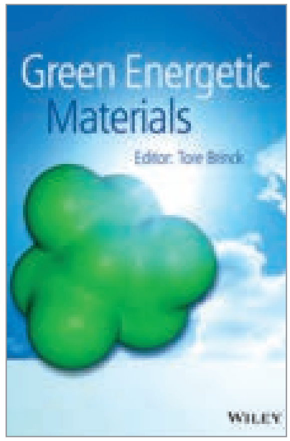
Biofuels, Solar and Wind as Renewable Energy Systems



Editor: David Pimentel
Publisher: Springer
504 pages

With a shortage of fossil fuels, especially oil and natural gas, and heavy use of biomass energy use occurring in both developed and developing countries, a major focus has developed worldwide on renewable energy systems. Renewable energy systems include wind power, biomass, photovoltaic, hydropower, solar thermal, thermal ponds, and biogas. Currently, a heavy focus is on biofuels made from crops, such as corn, sugarcane, and soybeans, for use as renewable energy sources. Wood and crop residues also are being used as fuel. Though it may seem beneficial to use renewable plant materials for biofuel, the use of crop residues and other biomass for biofuels raises many concerns about major environmental problems, including food shortages and serious destruction of vital soil resources. All renewable energy systems need to be investigated because humankind has only about 40 years of oil and gas reserves remaining. There is a 50 to 100 year supply of coal resources in the ground, but coal will become increasingly difficult to extract and will greatly increase the global warming threat. EF

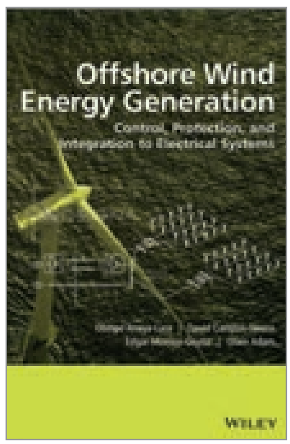
Green Energetic Materials



Editor: Tore Brinck
Publisher: Wiley
302 pages

Since the end of the 20th century, it has been increasingly realized that the use or production of many energetic materials leads to the release of substances which are harmful to both humans and the environment. To address this, the principles of green chemistry can be applied to the design of new products and their manufacturing processes, to create green energetic materials that are virtually free of environmental hazards and toxicity issues during manufacturing, storage, use, and disposal. Active research is underway to develop new ingredients and formulations, green synthetic methods, and non-polluting manufacturing processes. *Green Energetic Materials* provides a detailed account of the most recent research and developments in the field, including green pyrotechnics, explosives, and propellants. From theoretical modelling and design of new materials to the development of sustainable manufacturing processes, this book addresses materials already on the production line, as well as considering future developments in this evolving field. EF

Offshore Wind Energy Generation: Control, Protection, and Integration to Electrical Systems



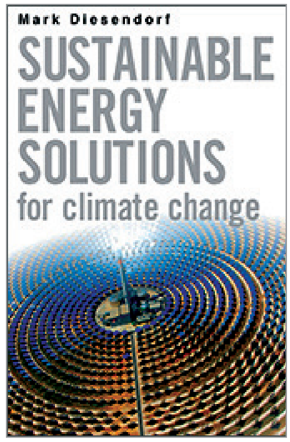
Authors: Olimpo Anaya-Lara, David Campos-Gaona, Edgar Moreno-Goytia, Grain Adam
Publisher: Wiley; 279 pages

The offshore wind sector's trend towards larger turbines, bigger wind farm projects, and greater distance to shore has a critical impact on grid connection requirements for offshore wind power plants. This important reference sets out the fundamentals and latest innovations in electrical systems and control strategies deployed in offshore electricity grids for wind power integration.

The book includes: all current and emerging technologies for offshore wind integration and trends in energy storage systems, fault limiters, superconducting cables, and gas-insulated transformers; protection of offshore wind farms illustrating numerous system integration and protection challenges through case studies; modelling of Doubly-fed Induction Generators (DFIG) and full-converter wind turbines structures together with an explanation of the smart grid concept in the context of wind farms. EF

Sustainable Energy Solutions for Climate Change

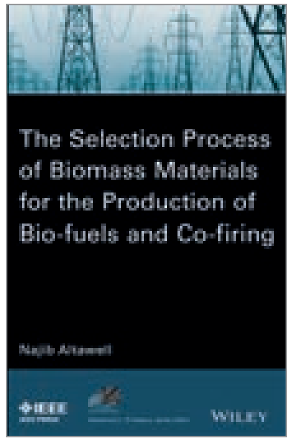
Renewable energy expert Mark Diesendorf issues a powerful challenge in this clear and comprehensive guide to the technology and policies we need to adopt to ensure an ecologically sustainable energy future for the planet. *Sustainable Energy Solutions for Climate Change* brings together the science, technology, economics, and policy issues to provide a unique and truly interdisciplinary approach. It details the enormous recent changes in the energy sector and profiles the renewable energy technologies that can transform our fossil-fuelled energy systems into ecologically sustainable ones. The book provides in-depth analysis of: scenarios for transitioning our polluting energy system to one based on the efficient use of renewable energy; sustainable transport and planning for better cities; why nuclear energy is not the answer; the politics and policies of climate change mitigation; myths about wind and solar energy and energy efficiency; what people can do to overcome vested interests and push reluctant governments to take effective action. EF



Author: Mark Diesendorf
Publisher: Readhowyouwant.com
619 pages

The Selection Process of Biomass Materials for the Production of Bio-Fuels and Co-firing

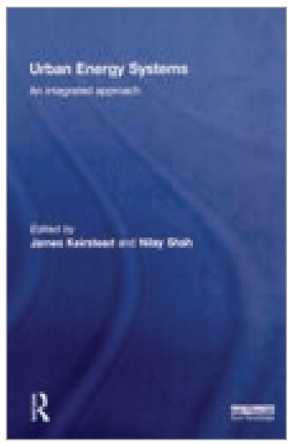
The Selection Process of Biomass Materials for the Production of Bio-fuels and Co-firing provides a detailed examination and analysis for a number of energy crops and their use as a source for generating electricity and the production of bio-fuels. Renowned renewable energy expert and consultant Dr Najib Altawell begins with the fundamentals of bio-fuels and co-firing and moves on to the main feature, which is the methodology that assists energy scientists and engineers to arrive at the most suitable biomass materials tailored to each company's business and economic environments and objectives. This methodology provides a framework whereby power-generating companies can insert their own values for each factor, whether Business Factor (BF) or Scientific and Technical Factors (S&T) or both simultaneously. The methodology provides a list of factors related to the biomass energy business. The average values have been obtained from the survey method and laboratory tests. These values are the standard values power companies can use if they need or wish to use them. EF



Author: Najib Altawell
Publisher: Wiley
384 pages

Urban Energy Systems

Cities are home to over half of the world's population, with millions attracted by the economic and social opportunities of urban life. But urban lifestyles demand reliable and sustainable energy services—to heat and cool our buildings, to power our homes and offices, and to transport ourselves and our goods. *Urban Energy Systems* looks at the technical and social systems that satisfy these service demands and asks how they might be provided more sustainably. Adopting a holistic approach, this book describes urban energy systems as complex interconnected systems. It shows how cities have evolved from consuming locally available fuels to centres of global energy networks with significant environmental impacts. New building and transportation technologies offer significant potential for improvement but only if technologies, demands, and institutions are analysed in an integrated manner. Drawing on analytical tools and case studies developed at Imperial College London, the book presents state-of-the-art techniques for examining urban energy systems as integrated systems of technologies, resources, and people. EF



Editors: James Keirstead and Nilay Shah
Publisher: Routledge
336 pages

RENEWABLE ENERGY TECHNOLOGY DEVELOPMENT

World's most environmentally sensitive tidal stream generator to hit the market

Renewable Devices Marine Ltd has already secured a private funding package, as well as a £100,000 worth of innovation funding form the Scottish Government. Within 18 months the company aims to have deployed the lowest cost, most reliable, and most environmentally sound tidal stream generator commercially available anywhere in the world.

The Capricorn Marine Turbine contains innovations relating to the following areas: The innovative Bk97 buoyancy control system allows for extremely simple and low cost deployment of the Capricorn turbine. Extremely accurate and reliable buoyancy control using the Bk97 system allows the turbine to be floated out to its deployment site, whilst also providing a very controllable means of sinking the turbine on to its foundations and raising it for maintenance purposes, with minimal sub-sea intervention from divers or underwater vehicles being necessary. The Capricorn Marine Turbine has a horizontal axis, contra-rotating, and twin rotor architecture. Each rotor has three blades, designed to be bi-directional in operation, thus negating the need for a yaw mechanism.

www.renewable-energy-technology.net/marine-hydropower-news/worlds-most-environmentally-sensitive-tidal-stream-generator-hit-market

Barriers to renewable/sustainable energy technologies adoption: Indian perspective

Rapidly increasing energy demand and growing concern about economic and environmental consequences call for renewable/sustainable energy technologies' adoption in India. Renewable/sustainable energy technologies have faced a number of constraints that have affected their rate of adoption. In this paper, an attempt has been made to identify and rank the major barriers in the adoption of 'renewable and green' energy technologies in the Indian context. Twenty-eight barriers have been identified from an extensive literature review. These identified barriers have been categorized into seven dimensions of barriers, which are Economical and Financial; Market; Awareness and Information; Technical; Ecological and Geographical; Cultural and Behavioral; and Political and Government Issues. Analytical Hierarchy Process (AHP) technique has been utilized for ranking of barriers to adopt renewable/sustainable technologies in the Indian context. All pair comparisons in AHP have been made based on experts' opinions (selected from academia and industry). Sensitivity analysis has also been made to investigate the priority ranking stability of barriers to adopt renewable/sustainable technologies in the Indian context. This paper may help practitioners, regulators, and academicians focus their future efforts in adoption of 'renewable/sustainable energy technologies' in India. Further, this understanding may be helpful in framing the policies and strategies towards adoption of renewable/sustainable energy technologies.

www.researchgate.net/.../265844904_Barriers_to_renewablesustainable_energy_technologies_adoption_Indian_perspective

Renewable energy powered membrane technology: A leapfrog approach to rural water treatment in developing countries?

Lack of access to safe drinking water remains a present concern in many developing countries, particularly in rural locations. Membrane water treatment technologies have the potential to remove microbiological and chemical contaminants reliably and simultaneously from a wide range of water sources. When powered by renewable energy, these systems are autonomous and have the ability to 'leapfrog' over installation of traditional infrastructure for electricity and water supply to reach remote communities. In this paper, current estimated costs for water, membrane plants, and infrastructure are compared to indicate the window of opportunity for these exciting renewable energy powered membrane (RE-membrane) technologies. General estimated costs for decentralized membrane systems are within the range of some untreated water costs in developing countries. Specific system costs, however, are process and location-dependent. The appropriateness of a successful approach thus depends partially on careful examination of these parameters. In view of the comparisons made here, the biggest hurdle to adoption of the RE-membrane technology in a remote location may not be cost, but rather sustainability issues such as the lack of skilled personnel for operation and maintenance, service networks, availability of spare parts, socio-economic integration, and adaptive capacity of communities to transfer and develop technology appropriate to local needs and circumstances.

www.researchgate.net/.../264982045_Renewable_energy_powered_ membrane_ technology_A_leapfrog_approach_to_rural_water_treatment_i...

Assessing the sustainability of renewable energy technologies using multi-criteria analysis: Suitability of approach for national-scale assessments and associated uncertainties

Multi-criteria analyses (MCAs) are often applied to assess and compare the sustainability of different renewable energy technologies or energy plans with the aim to provide decision-support for choosing the most sustainable and suitable options either for a given location or more generically. MCAs are attractive given the multi-dimensional and complex nature of sustainability assessments, which typically involve a range of conflicting criteria featuring different forms of data and information. However, the input information on which the MCA is based is often associated with uncertainties. The aim of this study was to develop and apply a MCA for a national-scale sustainability assessment and ranking of eleven renewable energy technologies in Scotland and to critically investigate how the uncertainties in the applied input information influence the result. The developed MCA considers nine criteria comprising three technical, three environmental, and three socio-economic criteria. Extensive literature reviews for each of the selected criteria were carried out and the information gathered was used with MCA to provide a ranking of the renewable energy alternatives. The reviewed criteria values were generally found to have wide ranges for each technology. To account for this uncertainty in the applied input information, each of the criteria values were defined by probability distributions and the MCA run using Monte Carlo simulation. Hereby, a probabilistic ranking of the renewable energy technologies was provided. We show that the ranking provided by the MCA in our specific case is highly uncertain due to the uncertain input information. It is important that future MCA studies address these uncertainties explicitly, when assessing the sustainability of different energy projects to obtain more robust results and ensure better informed decision-making.

www.econpapers.repec.org/RePEc:eee:rensus:v:39:y:2014:i:c:p:1173-1184

What drives the development of renewable energy technologies? Toward a typology for the systemic drivers

At present, governments are embarking on the ambitious undertaking of increasing their countries' market share of renewable energy. Political ambitions, however, are just one of the driving forces for energy companies to engage in innovative climate projects. Energy companies' perceptions of business opportunities are dependent on a set of factors that influence their innovation ambitions. This research operationalizes previous work on the main drivers of the establishment of Renewable Energy Technologies (RETs), with the aim of presenting an overview of the typical systemic drivers within a technological innovation system (TIS) framework. This leads to the proposal of a comprehensive typology and categorization of drivers of RETs. The typology is validated empirically by analyzing data on the development of four types of RETs (wind, solar, biomass, and wave energy) in eight European countries (EU-7 and Ireland). The study's results shed light on the multilateral drivers behind the development of RETs. Furthermore, a cross-case comparative study reveals the differences between drivers of RETs and the patterns of these drivers in different countries.

www.ideas.repec.org/a/eee/rensus/v38y2014icp834-847.html

Renewable energy resources: Current status, future prospects, and their enabling technology

Electric energy security is essential, yet the high cost and limited sources of fossil fuels, in addition to the need to reduce greenhouse gasses emission, have made renewable resources attractive in world energy-based economies. The potential for renewable energy resources is enormous because they can, in principle, exponentially exceed the world's energy demand; therefore, these types of resources will have a significant share in the future global energy portfolio, much of which is now concentrating on advancing their pool of renewable energy resources. Accordingly, this paper presents how renewable energy resources are currently being used, scientific developments to improve their use, their future prospects, and their deployment. Additionally, the paper represents the impact of power electronics and smart grid technologies that can enable the proportionate share of renewable energy resources.

www.ideas.repec.org/a/eee/rensus/v39y2014icp748-764.html

INDUSTRY REGISTRY

Solar Energy Systems International

Manufacturers of photovoltaic systems for lighting and pumping water. Heating water by solar energy for homes, hotels, baths, and swimming pools. They also produce energy using wind energy.

29, rue de Niger, Tunis 1002, Tunisie
Tel +216/1/780033
Email: ses@planet.tn

Solar23 GmbH

Manufacturers of PV grid connection, pumping , SHS, solar heating, and wind power. Also provides services in engineering, turnkey installations and projects, and rural electrification.

Zeitblomstr, 7, D-89073 Ulm, Germany
Tel +49/700/232323-00
Fax 01
Email: info@solar23.com,
Website: www.solar23.com

Hangzhou first PV Material Co Ltd

Leading manufacturer of Solar EVA and backsheet with 10 years of experience.

407 XiShu Street, Linan 311300
Hangzhou City, China
Tel/Fax: 86 571 63812086, 63710907
Email: sales@firstpvm.com,
Website: www.firstpvm.com

P.EnergySrl

Manufacturer of turnkey plants for the assembling of PV modules. More than 10 years of experience in PV equipments: Laminators, tabber and stringers, layup, framers, testers, and handling system. Customized and standard solutions, different levels of automation up to 120MW/year.

Via Caduti sul Lavoro, 15,
35014 Fontaniva, Italy
Tel +39 049 7966190
Fax +39 049 7968776
Email: info@penergy.it
Website: www.penergy.it

Kuraray Europe GmbH

First manufacturer of specifically designed PVB film for solar/ photovoltaic module lamination Division TROSIFOL

Mülheimer Straße 26,
53840 Troisdorf, Germany
Tel +49/2241/2555-203
Fax +49/2241/2555-299
Email: bernhard.koll@kuraray.eu

FERON GmbH

Manufacturer of front- and backsheets for photovoltaic modules.

Hammerbenden 1-13,
D-52355 Dueren, Germany
Tel +49-2421-5905-0,
Fax 67
Email: info@feron.de
Website: www.feron.de

SAMIL POWER CO.,LTD

Manufacturer of Grid-connected PV power inverters and other PV system accessories for residential use and commercial power stations.

No.52 Huigu Innovation Park,
Huishan District Wuxi,
Jiangsu Province, 214174 P.R.C., China
Tel +86/510/83593131
Fax 83593136
Email: info@samilpower.com
Website www.samilpower.com

Duraluxe Energy Co., Ltd

It is a professional PV inverter manufacturer providing excellent and reliable products ranging from 1.5kW single phase to 500kW three phases, with complete certification.

No.2288, Cuihu No.5 Road,
Development Zone of Economy
& Technology
Tongling, Anhui, 244000, China
Tel +86/562/2196800
Fax 2196880
Website: www.duraluxe.com

Saj Electric Co., Ltd

Manufacturer of solar inverters and also offer PV monitoring software data acquisition and complete PV system application solutions.

No. 17, Xiangshan Road,
Guangzhou Science City,
GD, China
Tel +86-20-6660 8532
Fax +86-20-6660 8617
Email: info@sajelec.com
Website: www.saj-solar.com

ELTEK

Manufacturer of complete range of market leading PV inverters.

Graaterudveien 8,
3036 Drammen, Norway
Tel +47-32203200
Fax +47-38011310
Email: salesre@eltek.com
Website: www.eltek.com/solar

ECOPROGETTI Srl

Manufacturer of complete turnkey lines and personalized equipment for the production of photovoltaic modules.

Via dell'industria e dell'artigianato,
27/C Carmignano di Brenta, Italy
Tel +390-49-5991959
Fax 9459210
Email: info@ecoprogetti.it,
Website: www.ecoprogetti.it

FLEXcon Company

Manufacturer of customized and standard multi-layer flexible composites for barrier protection of crystalline and thin-film photovoltaic modules.

1 FLEXcon Industrial Park Spencer,
MA 01562-2642, USA
Tel +1/508/885-8455
Fax -1481
Email: mostiguy@flexcon.com

NATIONAL AND INTERNATIONAL EVENTS

Solar Energy Investment & Technology Forum 2014
November 12, 2014
Bengaluru, India
Website: http://www.ubmindia.in/renewable_energy/home

Intersolar India
Mumbai, India
November 18–20, 2014
Website: https://www.intersolar.in/en/intersolar-india.html

2nd Annual Solar Energy Southeast Asia congress
November 25–26, 2014
Impact Arena, Bangkok, Thailand
Website: http://seasia.solarenergyevents.com/

2nd International Conference and Exhibition on Energy Storage and Microgrids in India
December 4–5, 2014
New Delhi, India
Website: http://www.esiexpo.in/

Renewable Energy World Conference and Expo North America
December 9–11, 2014
Orlando, FL, United States of America
Website: http://www.renewableenergyworld-events.com/index.html

The Renewable Energy Latin American & Caribbean Conference & Expo – (RELACCx)
November 20–21, 2014
Fajardo, Puerto Rico
Website: http://relaccx.com/registration
Wood Heat Conference 2014
November 20, 2014
Newcastle, UK
Website: http://www.r-e-a.net/events/wood-heat-conference-2014

Renewable Energy Policy and Politics Series
December 4, 2014
London, UK
Website: http://www.r-e-a.net/events/renewable-energy-policy-and-politics-series

REA - STA Grid Working Group
November 20, 2014
London, UK
Website: http://www.r-e-a.net/events/rea-sta-grid-working-group

8th Annual International Tidal Energy
Summit 24th - 26th November 2014
November 26, 2014
London, UK
Website: http://www.r-e-a.net/events/8th-annual-international-tidal-energy-summit-24th-26th-november-2014

Next steps for smart grid development
November 26, 2014
London, UK
Website: http://www.r-e-a.net/events/next-steps-for-smart-grid-development

G20 Leaders' Summit 2014
November 15-16, 2014
Queensland, Australia
Website: http://energy-l.iisd.org/events/g20-leaders-summit-2014/

UNECE Sustainable Energy Week
November 17-21, 2014
Geneva, Switzerland
Website: http://energy-l.iisd.org/events/unece-sustainable-energy-week/

Biogas Sector Group Meeting
December 1, 2014
London, UK
Website: http://www.r-e-a.net/events/biogas-sector-group-meeting-011214

Investing in the UK green economy: priority sectors, challenges, and next steps for policy
January 22, 2014
London, UK
Website: http://www.r-e-a.net/events/investing-in-the-uk-green-economy-priority-sectors-challenges-and-next-steps-for-policy

IFPRI Workshop on Biofuels and Food Security Interactions
November 19-20, 2014
Washington D.C., US
Website: http://energy-l.iisd.org/events/ifpri-workshop-on-biofuels-and-food-security-interactions/

AfricaSolar 2014
November 20-22, 2014
Kadiogo, Burkina Faso
Website: http://energy-l.iisd.org/events/africasolar-2014/

UNFCCC COP 20
December, 1-12, 2014
Lima, Peru
Website: http://energy-l.iisd.org/events/unfccc-cop-20/

Global Landscapes Forum
December 6-7, 2014
Lima, Peru
Website: http://energy-l.iisd.org/events/global-landscapes-forum-2/

15th Delhi Sustainable Development Summit (DSDS 2015)
February 5-7, 2014
New Delhi, India
Website: http://dsds.teriin.org/2015/index.php

Renewable Energy at a Glance

Sector	Target		Achievements during the Month of July		Achievements during the month of July		Cumulative Achievements	
	2013–14	2014–15	2013–14	2014–15	2013–14 (% of Target)	2014–15 (% of Target)	(as on 31.07.2013)	(as on 31.07.2014)
I. GRID-INTERACTIVE POWER (CAPACITIES IN MW)								
Wind Power	2,500.00	2,000.00	608.2	561.15	96.2 (24.33)	83.45 (28.06)	19,661.15	21,692.98
Small Hydro Power	300.00	250.00	74.50	22.50	20.5 (24.83)	12.00 (9.00)	3,706.75	3,826.18
Biomass Power and Gasification	105.00	100.00	-	-	- (-)	- (-)	1,264.80	1,365.20
Bagasse Cogeneration	300.00	300.00	-	32.00	- (-)	- (-)	2,337.43	2,680.35
Waste to Power	20.00	20.00	-	-	- (-)	- (-)	96.08	106.58
Solar Power	1,100.00	1,100.00	152.56	106.00	79.56 (13.87)	- (-)	1839.0	2,753.00
Total	**4,325.00**	**3,770.00**	**835.26**	**721.65**	**196.26 (19.31)**	**95,45 (19.14)**	**28,905.21**	**32,424.29**
II. OFF-GRID/ CAPTIVE POWER (CAPACITIES IN MW_{EQ})								
Waste-to-Energy	10.00	10.00	-	-	- (-)	- (-)	115.57	132.73
Biomass(non-bagasse) Cogeneration	80.00	80.00	15.69	-	12.0 (19.61)	- (-)	486.84	531.82
Biomass Gasifiers *Rural*	1.00	0.80	0.10	-	- (10.00)	- (-)	16.89	17.48
Industrial	9.00	8.00	1.30	-	- (14.44)	- (-)	142.88	147.20
Aero-Genrators/Hybrid Systems	1.00	0.05	0.03	0.07	0.03 (3.00)	- (13.60)	2.14	2.32
SPV Systems	40.00	60.00	-	-	- (-)	- (-)	124.67	174.35
Water Mills/Micro Hydel	2.00 (500 nos.)	4.00 (500 nos.)	-	-	- (-)	- (-)	10.65 (2,131 nos.)	13.21 (2,643 nos.)
Biogas-based Energy System	2.00	-	-	- (-)	- (-)	- (-)	-	3.77
Total	**143.00**	**163.30**	**24.31**	**0.07**	**12.03 (16.77)**	**- (0.07)**	**906.83**	**1,022.88**
III. OTHER RENEWABLE ENERGY SYSTEMS								
Family Biogas Plants (numbers in lakh)	1.10	1.10	-	-	- (-)	- (-)	46.55	47.40
Solar Water Heating – Coll. Areas(million m2)	0.60	0.50	0.07	0.09	0.04 (11.67)	- (0.09)	7.07	8.19

Source: www.mnre.gov.in

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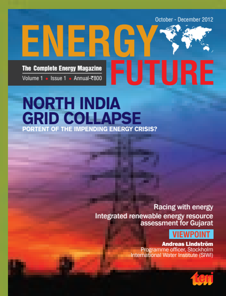

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