Summary Report of the Workshop on grid-integration of small scale decentralized renewable energy (DRE) systems organized by Prayas Energy Group along with NCPRE, IIT-B and held in IIT-Bombay on 3rd April 2012.

Introduction and Background: In the last few years, the rural electrification program under the Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY) has increased village electrification and rural household (HH) connections significantly. But today, nearly 33% of Indian HHs are still without access to electricity[1], though electricity distribution infrastructure is yet to reach only 7% of the villages.[2] It appears that there is further commitment under the 12th plan to quickly electricity the remaining villages.

In addition to the option of providing large scale access through the centralized grid, an important area which deserves serious attention for specific areas is distributed generation based on renewable resources (typically a few kWs to a few hundred kWs capacity). In this regard, both Ministry of Power (MoP), through its DDG (Decentralized Distributed Generation) Policy and Ministry of New and Renewable Energy (MNRE) through its various schemes have been promoting DRE. MNRE has been playing a significant role in remote rural electrification by implementing renewable energy projects in off-grid decentralized mode at the locations where extending grid electricity have been deemed unsuitable (economically or technically). However the field experience of such DRE systems has been sobering. A significant number of projects are lying idle for a variety of reasons (technical, high cost of generation from higher costs (lakhs/kW) of small scale renewables and the much higher O&M costs in remote locations, battery replacement costs (solar PV) and un-assured affordable biomass supply and other local social issues)

With the current drive of extending grid through RGGVY, one can expect that most of the un-electrified villages will be grid-connected soon. Few locations where the RGGVY infrastructure is in place, currently have decentralized renewable energy (DRE) based micro-grids to partially fulfill the local electricity needs. It is believed that the arrival of the centralized grid would potentially threaten the existence of the DRE projects, as the villagers will prefer the "cheaper" grid electricity over the costlier electricity from DRE generation. This is an added emerging risk or challenge for new projects, which would increase with time, especially as the RGGVY network covers larger areas.

If existing off-grid DRE projects possess the capability to seamlessly interface with the grid (considering the prospects of the centralized grid reaching these locations), it will considerably increase their viability and sustainability and further have positive implications for enhancing electricity access. MNRE in its 12th plan working group report and Forum of Regulators (FOR) in its December 2011 meeting too have pointed in the same direction. Since the centralized grid acts like a large battery, feeding electricity into the grid will ensure lowering of the costs of DRE projects by improving their Capacity Utilization Factors (CUFs). In the immediate future, pure off-grid projects could supply electricity through micro-grids and in the long run, the grid-connected DRE projects work complementary to the centralized grid supply. If techno-economically feasible, DRE projects coupled with smart grid features could also isolate from the grid (when the grid is

[1] Source of Lighting; Houselisting and Housing Census Data Highlights – 2011; available at http://www.censusindia.gov.in/2011census/hlo/hlo_highlights.html

[2] Progress report of village electrification as on 31.12.2011, Central Electricity Authority (CEA), Govt of India

down) and supply only the micro-grid. Grid connected DRE would not be limited to rural areas in the future, given the emergence of urban rooftop solar as a serious contender with the sharply falling solar PV prices. The existing DDG guidelines already have various enabling policy provisions for grid integration. Section 16 (v) states that if the grid reaches the village then power from the DDG project can be exported to the grid and imported from the grid as and when required. An amendment to clause 3, passed in March 2011 further states that if a developer sets up a DDG project with excess capacity, this power can be exported to the grid, however the subsidy on the project will be limited to that needed for supplying electricity in the village and that the cost of excess capacity and for transmission will be borne by the developer.

Whenever off-grid projects would interface with the centralized grid, a variety of regulatory issues (generation and consumer tariffs, cost sharing of grid extension infrastructure, possible use of existing distribution lines etc) would need the consideration of the Regulator. Additionally projects would have to conform to grid connectivity standards of the CEA and requirements from the State grid code/local DISCOM if any. There are currently only a handful of rural small scale DRE projects in India which are grid-connected. Sustainable and scalable deployment of grid-connected DRE projects, however, will require a comprehensive framework covering technical, financial, operational, policy and regulatory aspects.

The Central Electricity Authority (CEA) is preparing regulations specifying technical standards for connectivity for the distributed generation sources with the objective of providing uniform connectivity standards so as to ensure a safe and reliable operation of the electricity system. With a view to further discussion around this issue, the Prayas Energy Group, along with the National Centre for Photovoltaic Research and Education (NCPRE), Indian Institute of Technology Bombay (IITB), organized a one-day workshop to explore various aspects of grid integration of small scale DRE projects. The objective of this workshop was to provide a platform for sharing emerging issues and consolidate suggestions on the way forward on the issue of grid integration of DRE projects. The workshop was divided into three sessions, (1) Sharing of experiences from existing grid connected DRE projects in India and some other countries, (2) Technical considerations in grid connected DRE systems and (3) Policy and regulatory aspects of grid integration. Each session was followed by an extensive 45 minute discussion. There were 10 speakers in the workshop, which was attended by nearly 70 professionals from different States, representing different stakeholders including DISCOMs, ERCs, CEA, Developers, Consultants, Financial Institutions, R&D centres, academia and NGOs.

Session 1 (10.20 -12.30): Case studies of grid-connected DRE systems in India and some international experiences:

1) The first presentation was by **Dr S P Gon Choudhury,** President NBIRT, who explained that grid connectivity of small scale DRE cropped up as issue since off-grid DRE cannot support 24X7 power and hence could only partially satisfy people and since grid based power is (apparently) a lot cheaper than DRE. Under the present situation of electricity shortages, DRE can play a major role in supplementing the grid power. He suggested three major actions to facilitate grid integration, namely, (1) social awareness, (2) facilitating commercial loads and lowering consumer tariffs to compete with the grid tariffs and finally (3) keep a connectivity provision with conventional grid with the possibility of bulk purchase and distribution of power through the

network. Lastly he shared with everyone the experience of the 2X30 kWe biogas based micro turbine project connected to the grid in Purulia and the challenges of integration, especially in weak Indian grid conditions.

2) The second presentation was by **Dr Chris Greacen** who joined the audience via skype video call from Washington State, USA and spoke about his experience in grid connected DRE systems in Thailand and Tanzania. Grid integration of DRE as a concept took root in Thailand, when the grid reached villages which had functioning off-grid micro hydro systems after which people questioned whether once could hook the system to the grid and sell power back?. This eventually led to the formation of the Thai VSSP regulations (a set of technical and commercial regulations on grid integration along with a standard PPA agreement). The success of the Thai program was that it started small, with low-cost projects and gave utilities time to become comfortable with the concept, however it is still not well integrated into national planning process. A similar process is also currently underway in Tanzania. His advice was to explore low hanging fruits to go forward on grid integration, where challenges are easy to handle. For more on Thai and Tanzanian regulations, please see http://www.eppo.go.th/power/vspp-eng/ and www.ewura.go.tz/sppselectricity.html respectively.

3) The final presentation in the first session was by **Dr Arun Kumar**, Director of the Alternate Hydro Energy Centre, IIT-Roorkee. He spoke at length on the issue of grid connected micro hydro systems and began by noting the difference between "social sector" and fully "commercial" projects. He then described in detail a case study of the Ramgad Micro hydro project in Nainital, which is a prime example of an earlier off-grid project being converted successfully into a grid connected one. Electricity is locally consumed and only excess is fed into the grid. The tripartite agreement between AHEC, the VEC and UREDA has gone a long way in making the project sustainable. With regard to Arunachal Pradesh, Dr Kumar noted that 67 micro hydro projects are under implementation, all presently in off-grid mode but considering the grid extension in next 10-20 years, these projects are provided with the grid integration option through excitation system of the generator with automatic power factor controller and a synchronization panel. He ended his talk with a discussion on the comparative cost effectiveness of Transmission line extensions and grid integration of several projects in Arunachal. For more on AHEC please see http://www.ahec.org.in/

A few important issues that emerged from the discussion:

(a) Grid integration in weak rural Indian grids (varying voltage and frequency coupled with load shedding) is quite a challenge and hence may not be possible in all cases. Hence the importance of developing indigenous technology, especially w.r.t. power electronics which would be suited to work in Indian conditions. There is a need to look more carefully into the commercial and social issues prior to looking at grid integration. Dr Gon Chaudhary noted that the Purulia micro turbine project suffered a lot of loss of generation since the turbines would stop generating in the load shedding period. It could only be started again with the support of a small battery bank and inverter.

(b) On the question by Mr Vartak on whether there are examples of grid connected (directly to the distribution network and not to the substation) micro hydro projects, Dr. Kumar replied that they are a few cases already implemented in this manner. Additionally Mr. Ramachandra, GM, BESCOM pointed out that a biomass gasifier project on these lines is operational in Karnataka.

(c) On the question of whether local people were deprived of power if earlier off-grid micro hydro projects became grid connected, Dr. Kumar replied that this was not the case and that the projects could operate in the off-grid mode and supply locally in case the grid was down.
(d) Renewable energy technology is rapidly evolving and one can imagine a scenario not far in the future when there will be a transition from centralized to DRE systems. One can also think of deploying DRE systems in urban metros where demand is high and so is the paying ability, instead of trying to first successfully deploy in the most adverse of rural Indian conditions. This could be the low hanging fruit for the DRE sector.

Session 2 (13:30 - 15:40): Technical considerations in grid-connected DRE systems

1. The post lunch session began with **Mr B K Jain**, the Chief Engineer from CEA explaining the provisions of the draft regulations for grid connectivity of distributed resources. These will be applicable to distributed systems connected to the grid below 33 kV. He gave details with regard to the technical requirements of over and under voltage tripping, harmonic current injection, DC current injection, anti-islanding, back-feed, synchronization and flicker. He also explained the provision of voltage and frequency sensing and time-delay function to prevent the distributed generator from energizing a de-energized circuit. Each project will have to comply with the CEA safety regulations 2010 and metering will be as per existing CEA metering regulations. He pointed out that these regulations are in the draft stage and will be made public for a formal public consultation at which stage interested stakeholders can give specific comments.

2. The second presentation was by **Mr A Velayutham** who spoke on system planning and operation strategy. He noted the dire need for comprehensive and integrated transmission planning and pointed out the responsibilities of the various stakeholders in this process. He then touched upon the grid operation which has significant DRE generation and the challenges of operating the grid with the variable nature of the RE generation and its effect on grid stability, frequency control, reactive power and power quality. He suggested the formation of a separate RE transmission agency/committee and a RE sub-LDC within each LDC. He also noted that voltage level reactive power pricing will have to be evolved and that Central and private transmission licensees will have to complement the efforts of the State Transmission licensee. If done well all this will lead to an improved voltage profile in rural India, loss reduction in Transmission and Distribution, improvement in reliability and quality of power to villages and improved power availability.

3. The third presentation, titled, “Grid Connection issues for Distributed Generation – Review and Standards” was given by **Prof Suryanarayana Doolla,** Dept of ESE, IIT-B. He presented a comprehensive comparison of international grid interconnection standards in which he compared standards from Australia, Manitoba Hydro, some utilities from USA and the industry norm, i.e. IEEE 1547. He compared these standards with respect to anti-Islanding protection, auto reconnection after a trip, AC and DC Isolation, Installation safety requirements, voltage regulation, harmonics, flicker, unbalance, transient over-voltage in grid, DC injection and power factor. The comparison concluded by noting that (a) To encourage DR penetration a broad standard/guidelines are required. (b) It is important that utility have control over the DR (at PCC), (c) Islanding should be encouraged, and (d) system study and testing of DR is required before placing the DR

into operation. He also noted that any new regulations should give all the technical requirements in detail and not just refer to other IEEE/IEC standards, which may not be easily available to all concerned stakeholders.

4. The final presentation in this session was by **Prof S.A Soman,** Dept of EE, IIT-B. He began by comparing Transmission (meshed) and Distribution (radial) systems. He then presented the findings of a study on the reliability indices and system attributes of Indian urban electricity distribution utilities in comparison to utilities in the West which showed that reliability is far lower in India. Hence the need to first and foremost improve the reliability and protection of the distribution system if one plans for DG. He noted the valid concerns and requirements of the grid operators and the DRE operators and suggested a strategy going forward in which (a) *"As a regulatory requirement, the Grid operators should declare a 'de minimus' power limit for DRE. Any DRE below this limit should not require any permission to connect to Grid and start operating as long as it meets the standard interconnectivity requirements. (b) For connecting DRE above the de minimus limit, a Grid impact study should be done to ascertain that no adverse impact is caused on Grid by DRE. (c) Grid should be bound by contract to maintain a minimum standard of performance with respect to availability and quality of Grid supply."* He finally presented the learning from two case studies in which he was involved, (a) Shalivahan Green Biomass Project and (b) Collector System for a Wind Farm in Gujarat. He aptly summarised the final take away point from his presentation, *"Distribution Systems should be improved if they are going to transport power from distributed generation resources."*

Session 3 (16:00 - 17:40): Emerging Regulatory and Policy issues in DRE grid integration

1. The first speaker in the final session was **Mr Vidyadhar Wagle** from Tata Power whose focus was on urban solar PV rooftop projects. He described two projects in detail, namely the already commissioned 60 kW plant at Carnac and the proposed 500 kW plant at Tata Motors in Pune. In both these cases the major point of contention was the point of inter-connection. As per the MERC RE Tariff regulations, it is defined as "*Inter-connection Point shall mean interface point of renewable energy generating facility with the transmission system or distribution system, as the case may be."* He then described three possible options for interconnection, (1) To the Transmission system which would entail a cost of 615 lakhs and though it would be as per existing regulations would involve a substantial loss in transforming the power from 270 V to 220 kV. (2) To the distribution system, which involves a reduced cost of 215 lakhs and needs one to lay a separate line for 3 kms to the nearest sub-station. (3) Connection to Tata Motors Internal System, which would involve a cost of only 35 lakhs and have minimal losses and lead time. The obvious proposed choice was number 3 but this would require a different metering arrangement. In summary, Mr Wagle proposed that small scale rooftop PV systems would find it economically non-feasible to connect to 11 kV or 33 kV transmission systems and should be allowed to connect directly to the grid (like net metering in the West) while ensuring system safety. Additionally a simple yet robust mechanism for monitoring and metering such systems needs to be put in place.

2. The next presentation was by **Mr Ajit Pandit** from ABPS Infra and he spoke in detail about the emerging issues with respect to grid integration of DRE. He categorised the issues in those related to A. Connectivity, B. Metering Arrangements, C. Energy Accounting, D. Scheduling Requirements, E. Administrative costs, F.

Wheeling Charges and Losses and G. RPO Compliance. With regard to connectivity he noted the MERC definitions of interconnection point and the procedure for connectivity under the draft CEA regulations but highlighted the issue of appropriate voltage level for DRE grid integration and whether this would change with regard to project size. Another issue is that of monitoring subsequent DG/back up capacity addition at the same connection point. On metering, whether existing CEA metering regulations are relevant or will need modifications to accommodate DRE or whether SERC should specify metering arrangement as per Grid Code. Other issues with respect to metering were metering location, other data storage requirements, type of meter and nature of metering requirement with respect to size of project. Energy accounting is another serious issue and needs a practical and effective mechanism to address it. This mechanism would have to specify the role of the host DISCOM with regard to joint meter reading and issuance of credit notes with regard to various commercial arrangements. Similarly the role of SLDC and procedure for energy accounting would need clarity. He concluded by noting possible solutions on each mentioned issue and further suggested that FOR could come out with Model Regulations & Model Connectivity Agreements for Grid integration of distributed RE projects.

3. The final presentation of the workshop was by **Mr Vaman Kuber** from Sol2Sys who spoke very briefly about rooftop solar PV systems with respect to net metering. He noted that there was some policy non clarity with regard to net metering while supplying at 440 V. The first concern he noted was with regard to the anti-islanding requirement which could potentially reduce the CUF factor of solar PV. He further explained the operation of grid connected PV rooftop systems with battery back up, which have the added advantage of powering critical loads in case of power failure but also have to bear the additional battery cost. He gave the examples of Germany's solar rooftop program and the recent example of the Gandhinagar 5 MW rooftop program. However grid integration of solar rooftop in a weak grid is a challenge albeit its known advantages of higher performance ratio due to reduced losses, meeting peak time demand and feeding local loads, improving power quality etc. To address the grid integration issue, he suggested customized LV grid interface standard for India which would bring clarity on voltage and frequency range for synchronization, time to connect and disconnect PV generator and metering configurations.

The presentations made during the event can be downloaded from the following link (http://www.prayaspune.org/peg/publications/item/170-workshop-on-grid-integration-of-small-scale-decentralized-renewable-energy-dre-systems.html).

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For more information on Prayas' activities and its publications please see www.prayaspune.org/peg

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