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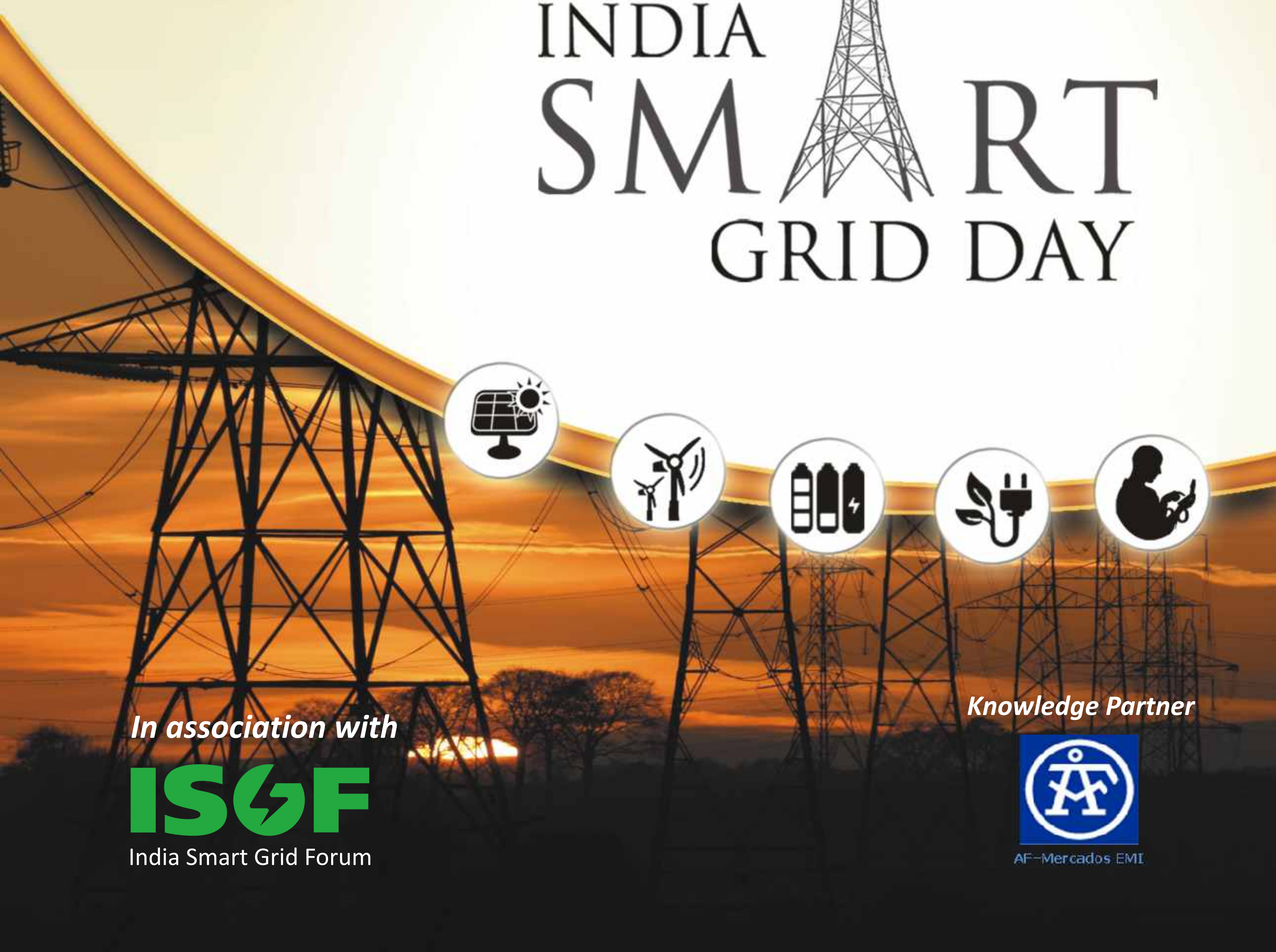
Ministry of Power
Government of India

FICCI

INDIA ELECTRICITY 2013

INDIA SMART GRID DAY



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Disclaimer

This paper has been prepared by AF Mercados Energy Markets India Pvt. Ltd. (AF Mercados EMI), a specialist energy consulting firm with service offering across power, oil and gas, and renewables. AF Mercados EMI has been actively working in the areas of smart grids and related aspects in India and outside. In India, AF Mercados EMI jointly with Nexant is working on the Smart Grid Module of the USAID's Partnership to Advance Clean Energy – Deployment (PACE-D) Program. The module involves wide range of activities in the area of smart grids covering policy, regulatory and deployment support. .

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CONTEXT OF SMART GRIDS IN INDIA

1. CONTEXT OF SMART GRIDS IN INDIA

1.1 CONCEPT OF SMART GRIDS

A Smart Grid can be defined as an interconnected system of information, communication technologies and control systems used to interact with automation and business processes across the entire power sector encompassing electricity generation, transmission, distribution and the consumer. The idea of a Smart Grid is to make the existing grid infrastructure as efficient and robust as possible, through the use of intelligence and automation, by encouraging active supply and demand-side participation and by promoting innovative business practices and regulatory environments that provide incentives for efficient production, transmission, distribution and consumption of electricity across the entire value chain.

The urgency for Smart Grids in India emerges from the key challenges that the industry is currently facing. India operates the 3rd largest transmission and distribution network in the world, yet faces a number of challenges such as: inadequate access to electricity, supply shortfalls (peak and energy), huge network losses, poor quality and reliability and rampant, theft. The evolution towards Smart Grid would address these issues and transform the existing grid into a more efficient, reliable, safe and less constrained grid that would help provide access to electricity to all.

1.2 BACKGROUND AND RELEVANCE OF SMART GRIDS TO THE INDIAN POWER SECTOR

The Indian power sector has come a long way since the introduction of 2nd wave of reforms heralded by the Electricity Act of 2003 (EA 03). This gave a major boost to the power sector by creating a conducive environment for enhanced private sector participation, which resulted in a large increase in generation capacity as well as investments in Transmission and Distribution as well as the introduction of a power market and power trading activities. In addition to this the focus of EA 03 has been to usher in reforms that aim at providing affordable, good quality and reliable power to consumers, making the electricity industry commercially viable and promoting efficiency improvements.

1.2.1 Power Generation

Power Generation has gained the most due to the entry of private players. The magnitude of capacity being added each year has increased manifold when compared to previous planning periods. Also, with the use of new and more advanced technologies, efficiency of thermal power plants has been improving and emission levels falling. Operational requirements related to scheduling and dispatch are driving the implementation of automation across the power system and for the Generators. All new plants now have sophisticated operational IT systems and the existing generation fleet is slowly upgrading to match.

Renewable Energy (RE) based electricity generation has gained prominence over the years. Several fiscal and policy measures have been introduced to promote RE. On an average, over 3000MW of RE installed capacity has been added every year with major contribution from the wind energy segment. Solar energy is gaining momentum through the Jawaharlal Nehru National Solar Mission (JNNSM) and state policies. Given the economics of coal and gas, fuel security issues and environmental concerns that are being faced, generation from renewable energy is increasingly assuming a central role in power-system design. Smart RE Control Centres which can forecast and monitor RE availability and potentially use energy storage to manage dispatch the of power to match grid conditions or manage demand through Demand Response (DR) programs to match capacity availability are expected to become critical to the future integration of RE in order to comply with the requirements laid down by the Indian Electricity Grid Code.

1.2.2 Transmission

The transmission sector in India is moving towards higher voltage levels of 1200kV and is introducing a higher level of automation and grid intelligence. Power Grid Corporation of India Ltd (PGCIL) has already installed Phasor Measurement Units (PMUs) for Wide Area Monitoring Systems (WAMS) on a pilot basis in select regions and is now pursuing a plan to install PMUs nationwide. Significant technological advancements such as increasing the capacity of transmission corridors through the use of Static VAR compensation and re-conductoring of lines using High Temperature Low Sag (HTLS) wires are also being taken up.

Managing these systems will require real-time monitoring and control only possible with a robust state-of-the-art communication system.

Power system operation is also under evaluation as a result of the disturbance in July 2012 and it is expected that policy reform will lead to more system control being given to the load dispatch centres and the phase out of the current Unscheduled Interchange (UI) mechanism designed to discourage DisComs and GenCos from deviating from published schedules. The UI mechanism is expected to be replaced by an ancillary services market, which would be managed by the power exchanges, thus further liberalizing power markets and providing greater transparency on costs and prices of services. Whilst in the beginning generators are expected to provide these services, discussions are taking place to pave the way for Demand Response programmes and Energy Storage facilities also to participate in the ancillary services market .

1.2.3 Distribution

The electricity distribution sector in India is currently in the worst shape, plagued by high network and financial losses in almost all states. There is an urgent need to bring in new technologies and systems to arrest these leaks. The Restructured Accelerated Power Development Program (R-APDRP) (see: http://www.apdrp.gov.in/) introduced by the GoI was aimed at reducing the network losses to 15%. Part-A of the program is aimed at creating IT Infrastructure and automation systems within utility operations, which until its introduction was largely missing in most of the distribution utilities in the country. And part B is aimed at strengthening the physical network. The R-APDRP is still under implementation and completion is expected during the 12th Five Year Plan. Once completely implemented, the program would provide a strong foundation for evolution to Smart Grids in the power distribution segment.

For the distribution sector, Smart Grids will mean the introduction of Demand Response programs, managing the expected introduction of electric vehicles and integrating distributed energy resources in a way that can help the DisComs balance local supply and demand and reduce peak time consumption. For this to happen, Advanced Metering Infrastructure (AMI) will be required as well as reliable communication infrastructure.

Building to Grid (B2G) or development of “Green Buildings” which can be incentivized to manage their consumption and even distributed energy resources to match grids conditions will also play their part in helping DisComs to manage supply and demand.

1.3 STRUCTURAL SUPPORT

In order to hasten the deployment of the Smart Grid initiatives in the country, the GoI created the India Smart Grid Task Force (ISGTF) and the India Smart Grid Forum (ISGF), and the pilot projects announced in 2012 are positive steps in this direction. The ISGF is divided into working groups focused on specific areas:

Working Group	Working Group Activity
1	Advanced Transmission Systems
2	Advanced Distribution Systems
3	Communications for Smart Grids
4	Metering
5	Consumption and Load Control
6	Policy and Regulations
7	Architecture and Design
8	Pilots and Business Models
9	Renewables and Micro Grids
10	Cyber Security

1.4 FOCUS OF THE INDIA SMART GRID DAY

While many developments related to Smart Grids have been initiated in the country, the concept and its applications are still at a nascent stage. There is much need for dissemination of knowledge and awareness and for capacity building at various levels. Accordingly, FICCI has partnered with the ISGF to organize the India Smart Grid Day as part of the India Electricity event and this will mark the launch of the **India Smart Grid Knowledge Portal** (www.indiasmartgrid.org), developed by Ministry of Power (MoP), ISGTF and ISGF.

In addition to this, the conference aims to discuss pertinent issues related to Smart Grids in India covering:

- International case studies on Smart Grids – roadmaps and deployments
- Smart Grids and network reliability

- Communication systems for Smart Grid applications
- Regulatory support for Smart Grid projects
- Cyber security
- Smart Grids and electric vehicles

The conference brings together national and international experience and intends to build Industry consensus on the direction to be pursued on the above aspects.

The focus of this paper is to provide general background to and context of Smart Grids with respect to the Indian Power Sector, and to serve as a guide with respect to concept, issues and key priorities. The following sections of this paper are organized according to the various conference sessions.

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REGULATORY SUPPORT FOR SMART GRID PROJECTS IN INDIA

2. REGULATORY SUPPORT FOR SMART GRID PROJECTS IN INDIA

2.1 CONTEXT AND CURRENT DEVELOPMENTS

The development of a dynamic regulatory environment is a pre-requisite to stimulate the market towards Smart Grids in India. Providing clear signals to different stakeholders such as utilities, investors and technology providers of the direction of the market and thus providing some certainty and confidence for the necessary investments. Through incentives and performance guarantees, consumers can be motivated to also take an active role and demonstrable cost benefits will convince regulators of the necessary investment requirements.

Regulatory support for Smart Grids is required across 3 key dimensions:

(i) Economic Regulation;

(ii) Safety and Standards; and

(iii) Awareness and Capacity Building

(See Figure 1)

Figure 1: Framework for Regulatory Support for Smart Grid Deployment

Economic Regulation	• Optimal tariff design that promotes Smart Grid Applications • Investment Approval Mechanism for Utilities
Safety & Standards	• Inter-operability standards • Standards for Cyber Security • Standards for Electric Vehicle Integration
Awareness & Capacity Building	• Consumer Awareness • Capacity Building for utilities, regulators, technology providers

Consumer awareness and capacity building at all levels will need to be pursued throughout to ensure buy-in and involvement.

It is important to mention that many regulatory instruments will need to be inter-related, and hence coherence across these will be necessary.

Within India several entities including ISGTF, BIS and CEA have already been working on a wide range of activities covering the different instruments required under the above framework. However, there is still a need for an institutional set-up that ensures strong coordination among all.

The following section lists out the key regulatory challenges being faced by the Industry related to Smart Grid deployment.

2.2 CHALLENGES & SUGGESTED INTERVENTION

		Challenges	Suggested Interventions
Economic Regulation	Facilitative Tariff Regime	Several of the Smart Grid initiatives such as Demand Response and peak load management require adoption of dynamic/ time of use (TOU)/ time of day (TOD) tariffs, which are currently absent in many states.	Introduction of appropriate tariff structures. Initially, participation in programs could be voluntary. Such efforts should be coordinated through the Forum of Regulators.
	Investment Approval Mechanism	Implementation of Smart Grid applications will require incurring capital expenditure. The regulatory guidelines in normal course would permit investments if the benefits outweigh the cost. However some benefits are intangible so in order to promote demonstration projects, liberal investment approval regulations are required to reflect the uncertainty associated with new technologies, new applications and the foreseen benefits.	Development of a conducive investment approval framework to promote innovation. Introduction of performance and service related incentives such as power quality and peak power. Recognition of transverse and less tangible benefits such as reducing emissions.

		Challenges	Suggested Interventions
Safety and Standards	Interoperability of Systems, Applications and Communication Technologies	Interoperability ensures compatibility between new systems, applications and communication technologies with old ones and among themselves. A lack of interoperability standards leads to deployment of technologies which are either not compatible with the existing system or may not have adequate interface facilities defeating the basic objective of Smart Grids to communicate between different components on real time basis. *One of the problems that faced with implementation of R-APDRP was the in-ability to read proprietary data from meters and lack of standardization in metering. In R-APDRP, while the issue was addressed to some extent by the adoption of IEC 62056 / Indian Companion Standard to BIS, this was limited to distribution transformer (DT) level.*	Interoperability standards for various applications/equipment. Definition of an interoperability roadmap at national level that maps out and comprehensively addresses various use cases/applications and presents an action plan for large scale deployment.
	Cyber Security	Various Smart Grid deployments will demand different levels of user access, access points and therefore security. Uniformity in such standards is much needed to ensure the smooth interaction of multiple systems and protection of data as well as operational systems/resilience to attack.	Regulations/standards for Cyber Security to ensure coordinated development across various Smart Grid applications. Current pilot projects could be used as test cases.
	Technical Standards for Electric Vehicles	Standards for integrating EVs as well as all distributed energy resources need to be defined to ensure the protection of the grid.	Grid code needs to be defined in consultation with EV manufacturers, charging station operators/aggregators and grid operators.

	Challenges	Suggested Interventions
Consumer Awareness	Implementation of Smart Grids will facilitate consumer participation with multiple options regarding provision of electricity or curtailment of load related to price, energy efficiency, renewable content etc. In this context, issues related to the roles and responsibilities of different stakeholders in: creating awareness, rules for enrolling consumers in programs, data protection etc. need to be defined.	Capacity Building is required for all stakeholders including policy makers, regulators, utilities, industry, research and academia and should cover: rate design, methods for approval of investments, technical standards, updates on new concepts and technology, roles and responsibilities of different stakeholders etc. Training of utility officials is required at all levels of management from senior management to field level officials and should cover: emerging technologies, operation of new systems, data management, data analysis etc. Education of consumers on the benefits of Smart Grids and how they can improve their electricity usage experience through availability of reliable and quality power and reduce electricity bills.

In order to support Smart Grid projects the respective state regulatory commissions can leverage following section of IE 03:

> *S 61 (c): " Commission…. shall be guided by the factors which would encourage competition, efficiency, economical use of resources, good performance & optimum investments"*

And Clause 5.9.6 of National Electricity Policy:

> "In order… difference between *electrical power demand during peak periods & off-peak periods would have to be reduced. Suitable load management techniques should be adopted for this purpose.* Differential tariff structure for peak and off peak supply…. *Regulatory Commissions should ensure adherence to Energy Efficiency Standards by utilities….*

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CYBER SECURITY FOR SMART GRIDS

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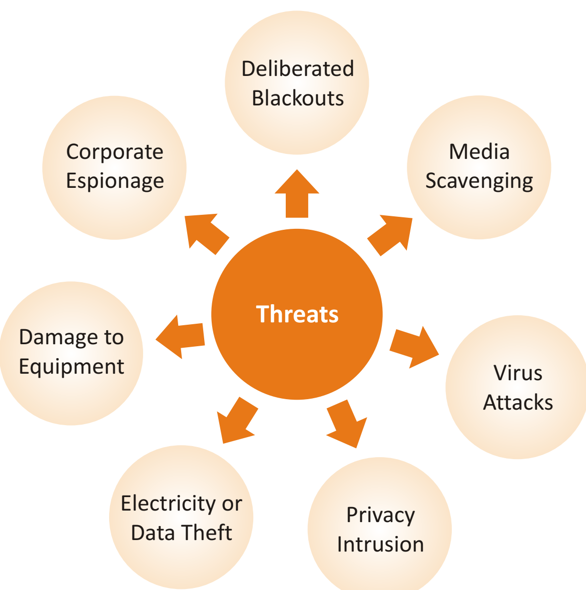
3. CYBER SECURITY FOR SMART GRIDS

3.1 CONTEXT AND CURRENT DEVELOPMENTS

Whilst the aim of smart grids is to improve reliability, stability and performance due to the increased integration of systems, levels of user access and access points they become more vulnerable to attack. At its worst, cyber-attacks may lead to complete collapse of a grid and consequently economic melt-down. Figure 2 shows the potential threats.

Figure 2: Cyber Threats



Taking advantage of weak points, an expert adversary could hack in to the IT and communication system and access operational applications. One of the common fears is injection of falsified data wherein meter data can be manipulated, leading to discrepancies in consumer's usage and loss of revenue. Similarly, a cyber attacker could also penetrate the entire control system raising serious grid security and management issues and posing threat to life and property. Cyber attacks could also be used for corporate espionage, using blackouts to hamper production leading to financial losses. Thus, timely identification and mitigation of such known or unknown threats is of prime importance. Effective cyber security solutions need to be put in place to prevent attacks thereby ensuring reliability and security.

The key objectives of 'Cyber Security in Smart Grids' include:

- ***Availability:*** of the grid even in the case of cyber-attacks. The system should be resilient to attack and not shut down in the event of an intrusion. Blackouts need to be prevented under all circumstances.

- ***Integrity:*** A huge amount of data is collected by sensors installed at various places within the grid and action taken according to this data. Unauthorized modification of data or insertion of rogue data would destabilize business and operational activities. Thus, integrity of data should be maintained to avoid malfunction.

- ***Confidentiality:*** Smart Grids collect various types of data/information related to customers, grid equipment, generators, and other market participants. The collected data needs to be secured from unauthorized access to prevent its misuse and maintain confidentiality.

Internationally, cyber security has been looked at as one of the most important characteristic of Smart Grids. The European Union has commissioned various studies to strengthen cyber security measures. It has also initiated various workshops to educate utility personnel to tackle cyber threats. It is also contemplating on introducing security certification of Smart Grid components. In India, as part of the working groups constituted under the ISGTF, Working Group 5 i.e. "Physical cyber security, standards and spectrum" covers the following activities: (i) creation and finalization of cyber security standards for Smart Grid deployment; (ii) Suggest modifications in the Electricity Act 2003 to address cyber security issues; and (iii) Capacity building on issues related to cyber security. In addition, ISGF working along with the ISGTF also has a working group on cyber security with the objective of developing Smart Grid cyber security requirement in India context, and to propose a risk assessment framework to evaluate risk of each Smart Grid element through its lifecycle. It also aims to develop a cyber-security approach and checklist useful for utilities and proposes risk mitigation measures, regulatory and policy measures for security, legal and information privacy issues. As per the current status, the working groups have finalized the detailed terms of reference, and are in processes developing detailed outputs to meet the above objectives.

As various entities involved in contributing towards the cyber security standards and the risk mitigation framework move ahead, there are several issues and challenges that will need to be addressed to ensure effective implementation. The following section lists out the key issues and challenges faced in implementing the cyber security standards for Smart Grid deployment.

3.2 CHALLENGES & SUGGESTED INTERVENTIONS

	Challenges	Suggested Interventions
Legacy Systems and Equipment	Legacy systems and equipment at the utility end present a key threat in designing and implementing cyber security solutions. These were installed and designed without cyber security in mind and hence are often integrated with other systems through relatively unsecured modes (including retrofits) offering avenues for cyber attack. In certain cases compatibility issues may also be encountered during such integration.	Security systems will need to be designed with additional firewalls to protect legacy systems See section on Regulation above (Interoperability)
Cost to maintain security	Increasing security will result in even higher volumes of data due to the encryption and decryption. To avoid congestion additional bandwidth will be required and consequently to maintain latency more sophisticated communication systems will also be required. Further additional data storage would also be required. There is often a trade-off between the level of security and available budget.	See section on Regulation above (project approval)
Capacity Development	Issues related to cyber security, the risks and possible solutions are not fully understood.	Capacity and awareness on common threats and solutions is critical at all levels. Necessary handholding of utility officials during initial stages of design and implementation will also be necessary for successful transition

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COMMUNICATION FOR SMART GRID APPLICATIONS

4. COMMUNICATION FOR SMART GRID APPLICATIONS

4.1 CONTEXT AND CURRENT DEVELOPMENTS

One of the most important requirements of a Smart Grid is a fast, reliable and secure communication network. Thus, communication technology can be thought of as the backbone of the Smart Grid. The efficiency and reliability of a Smart Grid immensely depends upon the choice of the underlying ICT and Operational Technologies adopted for various applications.

Irrespective of the functionality adopted (DR, WAMS, DAS etc.), the transfer of information from one point to another is a common feature across all Smart Grid applications. Technologies that provide 2-way communications are vastly preferred since most of the features implemented in Smart Grids require a bi-directional flow of information. Therefore, it is important to select the right method of communication from the beginning in order to avoid having to replace at a later date.

Communication technologies can be broadly classified into 2 types: Wireless and Wired. The difference being that Wired requires a physical medium like cable to transmit information whilst wireless uses micro-waves or radio-waves. The basic difference between these two technologies is that Wired technology needs a physical material medium like cable wires for data to be transmitted while on the other hand wireless technology uses micro waves or radio waves. At present, commonly used wireless technologies in Smart Grids are Zigbee and RF Mesh whereas Power Line Communication (PLC) is the commonly used Wired communication technology. While Europe has used PLC vastly, RF mesh has been popular in the US of A.

Table below provides relative comparison between the above technologies (the box below provides a brief description of each technology).

Characteristic	ZigBee	PLC	RF Mesh
Tech Type	Wireless	Cabled	Wireless
Network Topology	HAN	LAN/WAN	LAN/NAN
Data Rate	Up to 250kbit/s	250 kbps to 200Mbit/s	Up to 1Mbps
Delays	Order of seconds	< Zigbee	Least

Characteristic	ZigBee	PLC	RF Mesh
Advantages	• Less prone to failures • Operates on ISM band(unlicensed Spectrum) • High throughput • Low power consumption	• More secure as data is broadcasted over power lines • Low recurring cost • Infrastructure is widely available and is already in place • Robust	• Robust, efficient and affordable • More secure • High performance • Can collect information from hundreds of neighbourhood households and connect them to a utility's WAN. • Portable equipment • Scalable • Inherent self-organizing and self-healing intelligence keeps networks running
Disadvantages	• Limited memory size • Limited processing capabilities • Information security issues • Long delays • Limited data rates • Not suitable for traffic intensive applications.	• Channel is harsh and noisy • Low data rates • Not suitable for data intensive applications • High Capital Cost • Require bespoke engineering and qualified field engineers	• Equipment can be expensive • Lack economies for scale

The specific choice of technology depends on the: application being considered, geographical and population density considerations, coverage, costs, envisaged benefits, level of security required etc. These considerations often emerge as issues when utilities are confronted with selecting the optimal technology or combination of technologies for Smart Grid applications. These are elaborated in detail in the following section.

4.2 CHALLENGES & SUGGESTED INTERVENTION

<table>
<tr><th colspan="2">Challenges</th><th>Suggested Interventions</th></tr>
<tr><td>Standards</td><td>Absence of a harmonized set of standards for various communication technologies and applications hampers deployment of Smart Grids.
Proprietary systems prohibit scaling up, increase cost of integration and restrict adoption of advanced technologies.</td><td rowspan="4">Adoption of Open Standards:
Many forums suggest that adoption of open standards is critical for ensuring scalability of Smart Grid initiatives, reducing integration costs and promoting incorporation of new and innovative technologies.
This will also ensure that the development of equipment is based on uniform standards compatible from one system to the other.
However technology vendors would wish to protect their intellectual property rights. Therefore it is necessary for coordination among utilities, vendors, use-groups and standards bodies to work towards some level of compatibility.</td></tr>
<tr><td>Latency</td><td>Latency refers to the time taken by the signal to propagate through the network and reach its destination. Hence, latency can be thought as maximum rate at which information can be transmitted. The faster the information can be transferred the greater the volume.
Latency requirements depend largely on the functionality required. For instance, applications such as WAMS require very low latency. Hence, it is important to identify the latency requirement while choosing a suitable communication technology.</td></tr>
<tr><td>Security of Information</td><td>Security of information is important when selecting the communication technology. Different technologies provide different levels of security. Generally, while transmitting any information through the network, the information is encrypted and then decrypted at the receivers end ensuring its security. Hence the technology selected has to match the expected security levels.</td></tr>
<tr><td>Obsolescence</td><td>The pace of advancement in ICT is several times faster than that of the power sector.
When selecting a suitable technology it must be kept in mind that technology advancements are set to happen, hence the utility must be ready to depreciate the value of the assets according to their expected life span and not expect them to co-exist with equipment such as switchgear and transformers.</td></tr>
</table>

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ELECTRIC VEHICLES (EV) INFRASTRUCTURE AND POLICIY

5. ELECTRIC VEHICLES (EV) INFRASTRUCTURE AND POLICIY

5.1 CONTEXT AND CURRENT DEVELOPMENTS

Electric Vehicles (EV) run on electrically rechargeable batteries that can be charged from various charging points when the vehicle is not in use.

The current focus of the EV program in India is largely on mobility and pollution reduction in cities. The GoI has set up a National Council for Electric Mobility (NCEM) to promote electric mobility and manufacturing of electric vehicles in India. It will be aided by the National Board for Electric Mobility (NBEM) formed by the Ministry of Heavy Industries. The NCEM has formulated the National Electric Mobility Mission Plan 2020 (NEMMP 2020), and has set a target of 6-7 million units of new EV sales by 2020 with the expected liquid fuel savings of 2.2 – 2.5 million tonnes. The program has a budget of Rs. 230 billion of which around Rs. 18 billion has been allocated for R&D. The GoI support would be to the tune of Rs. 122.5 to 138.5 billionover the next 5-6 years.

With the adoption of Smart Grids several possibilities for integration of EVs with the grid have emerged and Vehicle to Grid (V2G) technologies are being developed on fast trak. These applications go beyond the conventional focus of EVs to reduce emissions in cities.

A Smart Grid can facilitate load management by providing options to shift the EV charging load to off-peak periods, thus obviating the need for additional generation. Further to only shifting load, when managed effectively the aggregated capacity of EVs sometimes described as a Virtual Power Plant (VPP) can be used to provide grid support services such as frequency regulation. Because EVs consume and can dispatch energy then they have the possibility to provide regulation up and regulation down, compared to DR, which can only regulate up by reducing demand on the system. This however, requires designing complex algorithms, a viable regulatory environment and strong 2-way communication and exchange of information/signals between the users and the utilities, to enable intelligent scheduling of vehicle charging.

Demonstration projects are currently underway Texas, USA, to test technologies that optimize household electricity use by integrating EV batteries, solar panels and home energy management systems (HEMS). Denmark has demonstrated effective integration of wind energy with EVs in the ongoing EDISON project. European Commission has a Europe-wide project named Green e-Motion with participation of leading utilities, EV manufacturers and technology providers all across Europe.

5.2 CHALLENGES & SUGGESTED INTERVENTIONS

	Challenges	Suggested Interventions
Policy and Regulatory Framework	Careful planning and appropriate policies that promote manufacturing, adoption and integration of EVs are critical to progress. Regulations need to specify the norms and procedures governing pricing, transactions and settlement.	Need for adequate policy and regulatory framework to promote the use of EVs and V2G applications. While the policy will provide overall guidance and direction, the regulations will need to define the application areas, rules for pricing, transactions, settlement mechanisms, commercial framework etc.
Technical Standards	Since the application of EVs to date has been restricted to public transport, technical standards defining norms for integration with the grid, safety and security standards or a grid code have not been defined.	Technical Standards for EV integration with the grid need to be defined. The Indian Electricity Grid Code needs to define the possible application areas for EVs and V2G operations.
Inadequate Infrastructure	Large-scale deployment of EVs will require adequate charging facilities including strong communication infrastructure, as the system would need to work in real-time to continually update information and provide price/frequency signals. Any additional electricity requirement will need to be calculated and included within the normal generation planning exercise. The risk of overloading already over-burdened Distribution Transformers is a very real risk.	Inter-ministerial coordination would be required to ensure that EV program provides for the required infrastructure for charging, distribution network infrastructure, additional electricity generation and the communication backbone.

	Challenges	Suggested Interventions
Availability of EVs during the peak time periods	In general, it is foreseen that available EV capacity will be lowest during peak times, as peak consumption coincides with peak driving times, which may pose issues making the owners of EVs reluctant to integrate with the grid.	Initially an incentive structure should be designed to encourage EV users to charge and discharge based on a specific pattern within specific time slots ensuring predictability and promoting better planning. As the system evolves, a more dynamic form of participation according to grid conditions can be encouraged. The use of EVs for public transport needs to be promoted to further reduce emissions from CNG and diesel as well as providing additional capacity resources.
Mass Charging of EVs during low load times	There could be issues if large numbers of EVs are put on charge simultaneously. In such cases, the grid may be overburdened and eventually the low load time may translate into a time of heavy burden on the grid.	
Battery Technology and Efficiency	Large-scale deployment of EVs will require evolution of battery technologies and efficiency. A significant improvement in the charge/discharge rate will be required especially when used for load balancing purposes. Design changes will also need to take into consideration the losses involved in charging and discharging.	Adoption of advanced battery technologies (with shorter charge/discharge time, better storage capabilities etc.) that facilitate V2G initiatives are critical. Additionally, research to develop charging stations independent of grid power should be encouraged. E.g. using solar power and harnessing energy generated from friction between wheels and braking system etc.

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NETWORK RELIABILITY: FUTURE TECHNOLOGIES

6. NETWORK RELIABILITY: FUTURE TECHNOLOGIES

6.1 CONTEXT AND CURRENT DEVELOPMENTS

The reliability problems in the Indian Power Systems were exposed by the recent grid failure. Reliability has been improved in the Inter-State Transmission System by enhancing capacity whereas the Intra-State Transmission system investments have lagged behind considerably.

The official REPORT ON THE GRID DISTURBANCE ON 30TH JULY 2012 questioned the overall adequacy and reliability of the power system on the following grounds:

a. Skewed load generation balance across regional grids
b. Tightening of frequency bands
c. Depleted reliability margins
d. Failure of defense mechanisms
e. Absence of primary response from generators
f. Insufficient visibility and situational awareness at Load Dispatch Centers
g. Lack of measures to enhance transfer capability
h. Inadequate dynamic reactive reserves
i. Impediments to the speedy restoration of the systems

The Report highlights issues beyond those listed above. There are currently adequate provisions in the Grid Code, which, if followed, would lead to alleviating some deficiencies and the remaining could be addressed through various “smart” transmission initiatives.

6.2 NON COMPLIANCE OF IEGC

Various Regulations notified from time to time provide for adequate level of reliability to be built in the system, however, there are several violations and issues observed. These are explained below:

i. Section 4.6.2 of the Indian Electricity Grid Code (IEGC) provides:

Reliable and efficient speech and data communication systems shall be provided to facilitate necessary communication and data exchange, and supervision/control of the grid by the RLDC, under normal and abnormal conditions. All Users, STUs and CTU shall provide Systems to telemeter power system parameter such as flow, voltage and status of switches/ transformer taps etc. in line with interface requirements and other guideline made available by RLDC. The associated communication system to facilitate data flow up to appropriate data collection point on CTU's system, shall also be established by the concerned User or STU as specified by CTU in the Connection Agreement. All Users/STUs in coordination with CTU shall provide the required facilities at their respective ends as specified in the Connection Agreement.

These provisions are fully not complied with.

ii. Further, Section 4.6.3 of the IEGC requires that

Recording instruments such as Data Acquisition System/Disturbance Recorder/Event Logging Facilities/Fault Locator (including time synchronization equipment) shall be provided and shall always be kept in working condition in the ISTS for recording of dynamic performance of the system. All Users, STUs and CTU shall provide all the requisite recording instruments and shall always keep them in working condition.

These are again not complied with – as reflected in causes (d) and (f) as mentioned above.

iii. Section 4.6.4 of the IEGC requires that

"All utilities shall have in place, a cyber security framework to identify the critical cyber assets and protect them so as to support reliable operation of the grid."

In contravention to these provisions, no utility in India has a cyber security framework in place.

iv. The IEGC requires that:

all thermal generating units of 200 MW and above and all hydro units of 10 MW and above, which are synchronized with the grid, irrespective of their ownership, shall have their governors in operation at all times in accordance with the following provisions.

This provision is violated all the time by most generators in India. This has been recognized in point (e) mentioned above.

v. The IEGC also requires that:

All SEBS, distribution licensees / STUs shall provide automatic under-frequency and df/dt relays for load shedding in their respective systems, to arrest frequency decline that could result in a collapse/disintegration of the grid, as per the plan separately finalized by the concerned RPC and shall ensure its effective application to prevent cascade tripping of generating units in case of any contingency.

This provision is again violated by most entities and this has been cited as an important reason for grid collapse on July 30 and July 31, 2012.

vi. Regulation 5.2 (o) of the Indian Electricity Grid Code (IEGC) also stipulates that:

All users, STU/SLDC, CTU/RLDC and NLDC shall also facilitate identification, installation and commissioning of SPS (including inter tripping and run-back) in the power system to operate the transmission system closer to their limits and to protect against situations such as voltage collapse and cascade tripping of important corridors/flow gates etc.

SPSs have been implemented at only limited locations in the central grid.

Reduced grid reliability can be attributed to lack of discipline and a system for monitoring compliance.

6.3 CHALLENGES & SUGGESTED INTERVENTIONS

Challenges	Suggested Interventions
Skewed Load Generation Balance across Regional Grids	Reliable demand forecasting tools are rarely utilized by system operators in India. Adequacy of spinning / reserve supplies in each control area could have helped to avoid overloading of inter-regional transmission lines. However, operation of such "tertiary controls" for load management requires ancillary services management / market mechanism. This in turn requires telemetry and strong communication links between generators, SLDCs/ RLDCs and sub-LDCs. The proposed introduction of ancillary services should help to resolve this issue. As discussed previously as and when smart grids evolve, initiatives such as DR, bulk energy storage, fine-tuned dispatching of RE and V2G initiatives could be used to provide such services.

Challenges	Suggested Interventions
Tightening of Frequency Bands	UI mechanism of balancing allows grid-connected entities to deviate from schedule at a price compromising grid security. The LDCs are mandated to maintain grid security and reliability and the proposed introduction of ancillary services would help to assist this. As discussed previously as and when smart grids evolve, initiatives such as DR, bulk energy storage, fine-tuned dispatching of RE and V2G initiatives could be used to provide such services.
Depleted Reliability Margins	Tripping of transmission lines and generators in a large power system is a random event, which necessitates re-dispatch of generators to provide contingency. Dynamic assessment of system reliability is critical which can be enabled through System Protection Schemes (SPS). SPS are widely accepted as an effective tool for increasing the utilization of power networks by enhancing the resilience of the power system towards rare contingencies. The introduction of WAMS should also help to provide and insight into grid stability allowing system operators to take preventative action.
Failure of Defense Mechanisms	In the grid disturbances in July 2012, failure of defence mechanisms/safety net in the form of load shedding schemes through Under Frequency Relays, Rate of change of frequency relays and islanding schemes in the Northern and Eastern Region were observed. In the future DR programmes could be used to support the system operation in the event that controlled load shedding is required.
Insufficient Visibility and Situational Awareness at Load Dispatch Centers	Considerable efforts are being made to provide wide-area visibility along with the associated applications at the RLDCs with the help of PMUs and WAMS. This needs to be continued at least to SLDC levels. Enhanced control through the use of SCADA at the LDCs would also help to protect the grid. Smart transmission / RE controls centres will help to facilitate increased integration of RE. These are currently yet to start in a pilot phase. Further enforcement of forecasting rules is required.
Lack of Measures to Enhance Transfer Capability	There is a debate between NLDC and CERC on whether SIL or thermal rating of a line should be considered for the purposes of determining TTC and ATC. Transfer capability of the system can be enhanced and challenges owing of over loading of a system can be handled through adequate compensation including dynamic compensation of lines. Reliability of the network can also be improved by deploying Dynamic Line Rating (DLR) system on high voltage transmission lines to provide grid operators real time information about the thermal capacity of the transmission line. The DLR system consists of tension and temperature sensors deployed throughout the transmission lines.

Challenges	Suggested Interventions
Inadequate Dynamic Reactive Reserves	Currently there are two SVCs of +140 MVAR capacity at Kanpur substation. In order to take care of contingencies like fault, high line loading, large load throw-off, dynamic reactive reserve is required at strategic locations in the grid. New technologies such as Transient Stability Control, FACTS etc are recommended. The proposed introduction of ancillary services including reactive power should help to resolve this issue. As discussed previously as and when smart grids evolve, initiatives such as DR, bulk energy storage, fine-tuned dispatching of RE and V2G initiatives could be used to provide such services
Impediments to the Speedy Restoration of the Systems	Indian power system currently has inadequate mechanisms to ensure start-up supply, supplies for black start, alleviate load generation-imbalance and reactive energy imbalance, built up subsystems/islanding, adequate communication and telemetry and provision from reactive resources. The proposed introduction of ancillary services including black start should help to resolve this issue.

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INSTITUTIONAL FRAMEWORK FOR SMART GRIDS IN INDIA

7. INSTITUTIONAL FRAMEWORK FOR SMART GRIDS IN INDIA

There is a need for a strong institution that can drive smart grid development in India. One designated entity should be made responsible for formulation of smart grid roadmap, implementation roadmaps, technology selection guidelines, standards guidelines, capacity building programs etc. Comprehensive and transparent investment plan is required at national level for all stake holders to make adequate investment plans in their respective domains for successful implementation of the projects in the intended time frame.

There can be two approaches here: strengthen the existing institutions or create a new institution. Existing institutions are India Smart Grid Task Force (ISGTF) and India Smart Grid Forum (ISGF). While ISGTF Is an inter-ministerial task force with representatives from various ministries and Govt institutions with a small secretariat housed in Power Grid Corporation of India, ISGF is a public private partnership body registered as a cooperative society. Both these bodies currently lack the organizational and financial strength to take up the above responsibilities, and also lack any authority. One option is to strengthen ISGTF with a permanent secretariat with larger number of staff who will work exclusively. And ISGTF can assign some tasks on selective basis to ISGF which could leverage the vast knowledge base of its members. ISGTF should have broader powers in taking decisions in matters related to smart grid developments. Another option is to create a Smart Grid Cell under MoP like the APDRP Cell. There are both advantages and disadvantages in this model.

In the second approach, an entirely new entity may be created in similar lines of National Mission for Electric Mobility recently launched by Ministry of Heavy Industries. A National Smart Grid Mission (NSGM) may be formulated and establish a National Council for Smart Grids (NCSG). The council may be made up of members from central and state utilities, academic institutions, regulators and standards institutions. The council shall be supported by a National Board for Smart Grids (NBSG) under the Ministry of Power (MoP). The NCSG shall formulate the NSGM, which shall define the short, medium and long-term action plan for implementation of smart grids in India. The action plan shall be recognized as a national objective and be included as part of the national planning process and thereby receiving adequate funding to carry out the work detailed in the action plan. The council shall work closely with all industry stakeholders; public and private and through a process of consultation will conclude all transverse issues related to: standards, regulation and policy, engineering design, process methodologies, technology selection etc. The council may be given statutory powers to approve the necessary rules and regulations.

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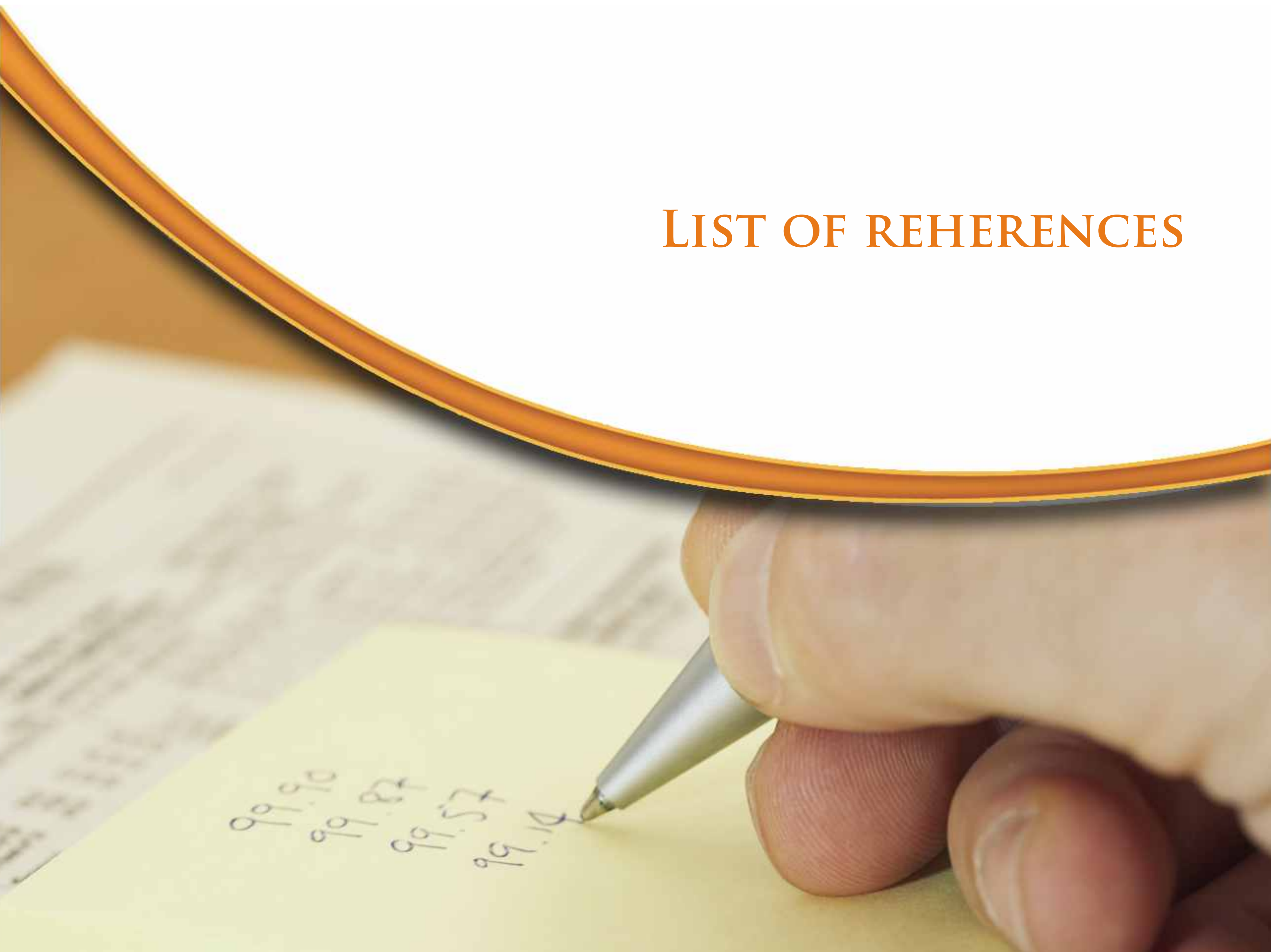

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About FICCI

Established in 1927, FICCI is the largest and oldest apex business organisation in India. Its history is closely interwoven with India's struggle for independence, its industrialization, and its emergence as one of the most rapidly growing global economies. FICCI has contributed to this historical process by encouraging debate, articulating the private sector's views and influencing policy.

A non-government, not-for-profit organisation, FICCI is the voice of India's business and industry.

FICCI draws its membership from the corporate sector, both private and public, including SMEs and MNCs; FICCI enjoys an indirect membership of over 2,50,000 companies from various regional chambers of commerce.

FICCI provides a platform for sector specific consensus building and networking and as the first port of call for Indian industry and the international business community.

Our Vision

To be the thought leader for industry, its voice for policy change and its guardian for effective implementation.

Our Mission

To carry forward our initiatives in support of rapid, inclusive and sustainable growth that encompass health, education, livelihood, governance and skill development.

To enhance efficiency and global competitiveness of Indian industry and to expand business opportunities both in domestic and foreign markets through a range of specialised services and global linkages.

India Smart Grid Forum

About ISGF

India Smart Grid Forum (ISGF), registered under Indian Societies Registration Act (Act XXI of 1860) is a Public Private Partnership (PPP) initiative of Ministry of Power, Government of India for accelerated development of smart grid technologies in the Indian power sector. The main objectives of ISGF are:

- To help Indian power sector to deploy smart grid technologies in an efficient, cost effective, innovative and scalable manner by bringing together all key stakeholders and enabling technologies
- ISGF will be a not-for profit voluntary consortium of public and private stakeholder members, research institutions and power utilities
- In addition to technical focus and expertise ISGF shall bring together stakeholders specializing in regulation, policy, and business case for smart grid
- ISGF will undertake research work and other efforts such as scoping the capabilities of smart grids in the Indian context through case studies, cost-benefit framework, technical advancements in the renewable energy sources and other ancillary activities
- ISGF will provide advice to Government, Regulators and Utilities in the form of reports and white papers, technical seminars etc

About AF Mercados EMI

Mercados - Energy Markets India Pvt. Ltd. (AF Mercados EMI) is a specialist consultancy firm supporting clients in liberalizing energy sectors, promoting efficient and sustainable energy markets, designing effective regulation, and assisting energy businesses to succeed. The firm is part of the AF Group headquartered in Sweden with over 7000 professionals across 100 offices in 23 countries.

Mercados EMI group is divided into the following main areas of expertise, covering Electricity, Oil and Gas, Environmental and Renewables sectors. Some of the key service offering of the company includes:

- Policy and Regulatory Advice
- Renewable Energy, Energy Efficiency and Climate Change
- Utility Management and Support Services
- Energy Market Analytics
- Business Implementation
- Business Strategy Development
- Transaction and Investment Advisory
- Training and Capacity Building

AF Mercados EMI has been actively working in the areas of smart grids and related aspects in India and outside.

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