Smart Grid - Opportunities and Challenges

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Presentation Outline

1. Background
2. Smart Grid Drivers
3. Issues & Challenges
4. Opportunities – Technology Options
5. R&D Initiatives
What is Smart Grid

• "Smart Grid" is today used as a marketing term, rather than a technical definition. For this reason there is no well defined and commonly accepted scope of what "smart" is and what it is not.

• The general understanding is that the Smart Grid is the concept of modernizing the electric grid. The Smart Grid comprises everything related to the electric system in between any point of generation and any point of consumption. Through the addition of Smart Grid technologies the grid becomes more flexible, interactive and is able to provide real time feedback.

http://www.iec.ch/smartgrid/
“End-to-End” Smart Grid
Leading Players by Market Segment

- Integrated Enterprise-Wide Advanced Control Systems
- Energy Management Systems
- Consumer Energy Management Systems

Distributed Generation and Storage
Networked Vehicles
Grid Optimization and Distribution Automation/Commns.
Demand Response
Meter Data Management (MDM)
Communication Layer (H/W, S/W, Control)

Power Layer Infrastructure
Utility
Infrastructure
Consumer

Evolution of Smart Grid: Generation → Transmission → Substation → Distribution → Home/Bldg. → Distributed Gen. and Storage
## Smart Grid Drivers & Technology Options

<table>
<thead>
<tr>
<th></th>
<th>AMI</th>
<th>Distribution automation</th>
<th>HEMS/BEMS</th>
<th>Energy storage</th>
<th>Demand response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increasing renewable generation</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Improved grid reliability</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Reduce non technical losses</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EV integration</td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Rising peak demand</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Ageing infrastructure</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

Source: Bloomberg New Energy Finance 2012
Smart Grid Drivers & Technology Options

- Advanced metering infrastructure
- Variable renewable energy integration
- Demand response
- Wind
- Distributed energy resources
- Renewable energy standards or targets
- System efficiency improvements
- Reliability improvements
- Enabling customer choice and participation
- Enabling new products, services, markets
- Energy efficiency improvements

Source: IEA Smart Grid Survey
Smart Grid Drivers: US vs Europe

**ECONOMIC**
1. $4.5bn stimulus
2. Job creation
3. Tech companies

**OPERATIONS**
1. Reduce opex
2. Improve asset mgmt

**RELIABILITY**
1. Improve SAIDI/SAIFI
2. Manage major storms

**ENERGY SECURITY**
1. Energy efficiency
2. Peak load management
3. Integrate RE / EV

**CLEAN ENERGY**
1. Efficiency
2. RE and DER
3. Electric vehicles

**LIBERALISATION**
1. Deregulation
2. Competition
3. Service innovation

**MARKETS / INTEGRATION**
1. European power markets
2. European super-grid

**OPERATIONS**
1. Reduce opex
2. Improve asset mgmt

Source: Bloomberg New Energy Finance 2012
Issues & Challenges – Customer Acceptance

2009: Cyber-Security

2011–2012: Cyber-Security, Privacy

2010 – 2011: Health (RF Concerns)

2009-2010: Meter Quality (Accuracy, High Bills)

Opt-Out

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www.sce.com/smartconnect

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Pilot Smart Meter Deployment in Melaka - Customer Experience

- Continuous customer engagement
- Localised events
- Community engagements
- Voluntary participation

- Customer benefits
- Incentive Campaign
- Web & Mobile Tools
- Smart Meter Web Portal
- Smart Meter Help Desk
- Installation Survey
- Social Media Engagement
- Online YouTube community engagement
- Personalized engagement

- Improved efficiency and availability.
- TNB SmartLiving enabled programs
- Pre-installation Letter
- Video/Advert
- Bill Inserts
- Door Hanger
Challenges & Critical Enabler - Interoperability

- As information technology (IT) and operations technology (OT) converge in the smarter grid of the future, network interoperability will be the starting point and precondition for all.

- Interoperability in multiple network technology must support end-to-end data quality and security, network system performance and application service provisioning and management.

Mission: To accelerate the implementation of interoperable Smart Grid devices and systems.
Challenges & Enabler – Infrastructure Development

- Shared vision for the smart electricity among stakeholders
- Widespread deployment of Intelligent Electronic Devices (IED)
  - Retrofitting of existing components are required to make them “smarter” as well as keeping the cost lower
- Infrastructure for integrated communications need to be fully developed

South Korea Smart Grid Test-bed with budget allocation of $200 million has been made ($68 mil public funds, $170 mil private investment)
Opportunity & Technology Options
RE Integration – Solar Forecasting

Advanced Solar Forecasting Method.
Accurate forecasting of solar resource is important to ensure the reliability and stability of the grid and distribution network.
Distributed Generation – Voltage Control

Coordinated Voltage Control.
Voltage limit violation is one of the factors limiting the penetration of DGs in distribution network. By coordinating DG and other voltage control devices, it is possible to control the voltage within the required limit.
**Smart Substation**

**Digitization & Self Healing:**
The smart substation provides a unique and compatible platform for fast and reliable sensing, measurement, communication, control, protection, and maintenance of all the equipment and apparatus installed in a variety of substations.
**SIMS**

- Substation Intelligent Management System: Intelligent system for monitoring and managing substation information.
- To maximize utilization of substation data from IEDs for supporting decision making process, engineering, operation & maintenance, fault investigation & diagnostic, and asset management

**IEC 61850 based SPACS**

- Substation Protection Automation and Control System that optimize substation integration of advances communication, data modeling, IEDs with IEC61850 as main core and enabling technology standard

**Process Bus**

- The Process layer of the substation that is related to gathering information, such as Voltage, Current, and status information from the transformers and smart sensors connected to the primary power system process
**Wide Area Intelligent System (WAIS).**

Integration of advanced sensors, communication and computing platform to achieve optimum grid system performance under abnormal system condition through automated actions.

- **Real Time Acquisition**
- **Real Time Analysis**
- **Real Time Assessment**

- On-line System analysis
  - Voltage/Transient Stability
  - Low Frequency Oscillation
  - Transfer Capability
  - Reactive power Reserve

- Real-time Monitoring
  - Freq, Voltage, Angle
  - Power Flow, Fault
  - Load Modeling

- Real-time Protection, Control
  - Emergency Frequency Control
  - Voltage Control/Load Shedding
  - System damping Control
  - System Isolation/Restoration

- Visualization
Energy Information & Demand Management

Real-time monitoring of energy consumption via mobile application/in-home displays or similar devices.

- Energy Supplier/distributor/sales company providing online access to customer energy usage.
- Incentives (reward for reducing overall energy consumption).
- Access to energy efficiency information (in-home display, mobile, websites).

<table>
<thead>
<tr>
<th>DEMAND RESPONSE PROGRAM</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Direct Load Control</td>
<td>Sponsor remotely shuts down or cycles equipment</td>
</tr>
<tr>
<td>2 Interruptible Load</td>
<td>Load subject to curtailment under tariff or contract</td>
</tr>
<tr>
<td>3 Emergency Demand Response</td>
<td>Load reductions during an emergency event \ Combines direct load control with specified high price</td>
</tr>
<tr>
<td>4 Load as Capacity Resource</td>
<td>Pre-specified load reductions during system contingency</td>
</tr>
<tr>
<td>5 Spinning Reserves</td>
<td>Load reductions synchronized and responsive within the first few minutes of an emergency event</td>
</tr>
<tr>
<td>6 Critical Peak Pricing w/Control</td>
<td>Combines direct load control with specified high price</td>
</tr>
<tr>
<td>7 Non-Spinning Reserves</td>
<td>Demand-side resources available within 10 minutes</td>
</tr>
<tr>
<td>8 Regulation Service</td>
<td>Increase or decrease load in response to real-time signal</td>
</tr>
<tr>
<td>9 Demand Bidding and Buyback</td>
<td>Customer offers load reductions at a price</td>
</tr>
<tr>
<td>10 Time-of-Use Pricing</td>
<td>Average unit prices that vary by time period</td>
</tr>
<tr>
<td>11 Critical Peak Pricing</td>
<td>Ratio/price to encourage reduced usage during high wholesale prices or system contingencies</td>
</tr>
<tr>
<td>12 Real-Time Pricing</td>
<td>Retail price fluctuates hourly or more often to reflect changes in wholesale prices on day or hour ahead</td>
</tr>
<tr>
<td>13 Peak Time Rebate</td>
<td>Rebates paid on critical peak hours for reductions against a baseline</td>
</tr>
<tr>
<td>14 System Peak Response Transmission Tariff</td>
<td>Rates/prices to reduce peaks and transmission charges</td>
</tr>
</tbody>
</table>
**Smart Mobile Application: A Revolution**

Needs advance application to interact with the features available in smart home.

- Near real-time energy consumption view
- Usage profile
- Bill payment
- Value added services
- Advance automation
- Remote control on smart appliances

Benefits of smart mobile application:

- Improve service and reduce costs on-the-go with real-time performance, customer, and market trend analyses
- Speed up response and offer new services by bringing customers closer to utility business
- Empower customers to consume energy more efficiently and reduce stress on the network

**Malaysian mobile smart phone penetration to hit 60% in 2 years.**
Source: Business Times 26th April 2013

**46% of smart phone users in Malaysia are 29 years old and below –MCMC**
(Potential to become TNB new customers in few years time as they start having own house)
Customer Energy Management: Customer Impact

- Utility to manage and monitor smart home appliances, EV charging, RE and storage to optimize energy usage
- Smart Home Area Network Implementation
- Secured ICT infrastructure

- Advanced automation control and optimization of energy usage using AI
- Management of the lighting, cooling system, etc

BEMS – Building Energy Management System

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Communication

Capability of managing communication access is important to ensure data from remote site can be accessed in secure and timely manner.
Data Analytics

The primary goal of data analytics is to help companies make better business decisions by analysing huge volumes of transaction data as well as other data sources that may be left untapped by conventional business intelligence (BI) programs.
Network Assets – Diagnostic Technology

- Online technology requires no system outages for condition assessment
- Real-time monitoring is continuous monitoring which give instantaneous indication on the health of the transformer
- Self diagnostic (autonomous system) need less human intervention in assessment of the health of the transformer

**Online Transformer Monitoring**

1. Cooling protection
   - Low oil level
   - Ambient temperature

2. Communication (wired, wireless or cellular)

3. Overload protection
   - Voltage, Current, Frequency
   - Active Power, Apparent Power, Power Factor
   - Active Power Angle, Tan Phi, Cos Phi
   - Remote operation LBS or MCCB

4. Core and coil protection
   - Dissolved gas (Buchholz Relay)
   - Moisture in oil

5. OLTC (optional)
   - Tap position and counter
   - Time since last through tap position
   - Low oil level

 Transformer monitoring application suite

R T U
**TNB Research – Overview**

- Established as a department in TNB, and evolved into a subsidiary in 1993.
- It is now a not-for-profit centre for electricity and environmental research.
- In 1997, TNBR received approval from MIDA as an R&D status company and became eligible for many governmental incentives.
- Today, TNBR is focusing on conducting R&D that adds value and aligns to TNB corporate needs as well as national aspirations.
- In April 2012, TNBR established its wholly owned subsidiary TNBR Quality Assurance and Testing Services (TNBR QATS) with the mission to leverage on Laboratory and technical services business.
- In February 2013, TNBR established a JV company Gunung-Tenaga to focus on environmental services beyond Malaysia.

**KEY COMPANY DATA**

- Workforce: 276 (as at September 2013)
- R&D Funding: ~RM 46 million (FY2013)
- R&D Value Creation: ~RM 36 million (FY2013)
**TNBR Core Business- Services**

**Scientific Services**
- Accredited to ISO/IEC 17025
- Largest and well equipped laboratory in the country
- Oil Fuel Lab received ‘Certificate of Excellence’ for proficiency testing by Institute Inter-laboratory Studies, Netherland

**Technical Services**
- Forensic Engineering Group (FEG)— conducts failure analysis on failed equipment
- Plant Inspection Services (PINS)— conducts condition assessment of power plant components

**Quality Assurance**
- Accredited to MS ISO/IEC 17020
- Auditors are certified Quality Auditor (CQA) granted by the American Society for Quality (ASQ)
- Experience in conducting inspections and audits all around the globe
TNBR Core Business- Applied Research

- Fuel & Combustion
- Power Plant Technology
  - Thermal
  - Hydro
- Material Engineering
- Material Laboratory

- Utility Automation
- SCADA
- Power System Optimization
- Lightning & Earthing

- Environmental Engineering
- Environmental Science & EIA
- Civil & Structure Engineering
- Geoinfomatic
- Water & Air Laboratory

- Primary equipment (Transformer, Switchgear, Cable)
- Advanced Diagnostic Techniques
- Online Condition Monitoring
- Losses, Power Quality And Energy Systems Study
**Low Carbon Power Generation Technology**

Objective: To develop an Integrated Gasification Combined Cycle (IGCC) pilot research plant and position TNBR as referral for IGCC research in Malaysia.

**Emission & Waste Management Technology**

Objective: To develop a carbon capture pilot plant for mitigation of CO2 emission and to position TNBR as referral on Carbon Capture for TNB.

**Green Energy Technology**

Objective: Utility Solar Solutions – Focusing on Solar conversion technologies, TNBR aims to be in the position to advice and consult on solar plant optimisation, maintenance, performance enhancement & life extension.

**Smart Grid Technology**

Objective: The application of smart grid technologies in managing network assets and utilisation, increase operation efficiency, reduce widespread outage, enhance reliability & sustainability and provides value-add service offerings to customers.
TNBR Advanced Research Program – Smart Grid Technology

**Program Objectives:** The application of smart grid technologies in managing network assets and utilisation, increase operation efficiency, reduce widespread outage, enhance reliability & sustainability and provides value-add service offerings to customers.

![Smart Grid Diagram](image-url)

- **Smart Substation**
- **Advanced Sensing & Analytics**
- **Advanced Metering Infrastructure (AMI)**
- **Reliable and Self Healing Grid**
- **AMI & Value Add Services to Customers**
- **Asset Optimisation & Management**
- **Smart Grid Technology**
- **Low Carbon Power Generation Technology**
- **Emission & Waste Mgt Technology**
TNBR Smart Grid Test Bed

The implementation of this activity has the following key features:

- **Support TNB Smart Grid Initiatives**

- Development and **Assessment of Communications & Information Infrastructure** to improve electrical system operation. The attributes include:
  - *Bi-directional and Open Standard communication platform*
  - *Able to support multiple services*
  - *Reliable, redundant, high availability & secured*

- **Platform to conduct advanced and further trials** on other Smart Grid Applications
**Wide Area Intelligent System (WAIS)**

- Program aim: to conduct R&D activities to enhance the reliability and security of the TNB grid system, and allow maximum utilization of TNB assets.
- Focus areas: Monitoring, Control and Protection of TNB Power Grid System

**WAIS APPLICATIONS**

- **2007 - 2012**
  - WAMS Based Monitoring System Application
  - WAMS Based Protection System Application

- **2012 - 2015**
  - Coordinated Voltage Control
  - Central Area Blackout Prevention System (Control Islanding)

**Sensors** – Synchronphasor, IEC61850 devices, RTU, Remote I/O, Power plant Distributed Control System, SCADA/EMS, HVDC control system, Smart meters etc

**Actuators** – IEC61850 devices, RTU, Remote I/O, Loads, Power plant Distributed Control System, HVDC control system, Smart Meters etc
Providing a platform, infrastructure and facilities for verifying, enhancing, advancing, managing, testing and training in the area of IEC 61850 based substation automation system.

Utilising IEC 61850 Communication Standard, IEC 61850 based substation automation system and other related technologies for successful application and adoption in TNB system.
Real-time Line Rating Embedded Monitoring System at TNB Transmission Lines

- To support intelligent line overload management system by providing actual line rating information in real time
- Embedded system- Real-time Application Processor (RTAP) of the WAIS provide data sharing platform with other engineering application e.g. SCADA system
**TNBR Advanced Research Program – Green Energy Technology**

**Program Objectives:** Utility Solar Solutions – Focusing on Solar conversion technologies, TNBR aims to be in the position to advice and consult on solar plant optimisation, maintenance, performance enhancement & life extension.
Thank You

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The cyber security objectives can be classified into the following three categories [47, 49].

(i) **Integrity.** Protecting against the unauthorized modification or destruction of information. Unauthorized information access opens the door for mishandling of information, leading to mismanagement or misuse of power.

(ii) **Confidentiality.** Protecting privacy and proprietary information by authorized restrictions on information access and disclosure.

(iii) **Availability.** Ensuring timely and reliable access to information and services. Availability can be compromised by disruption of access to information which undermines the power delivery.