CHAPTER 1

Smart grid review and world trends
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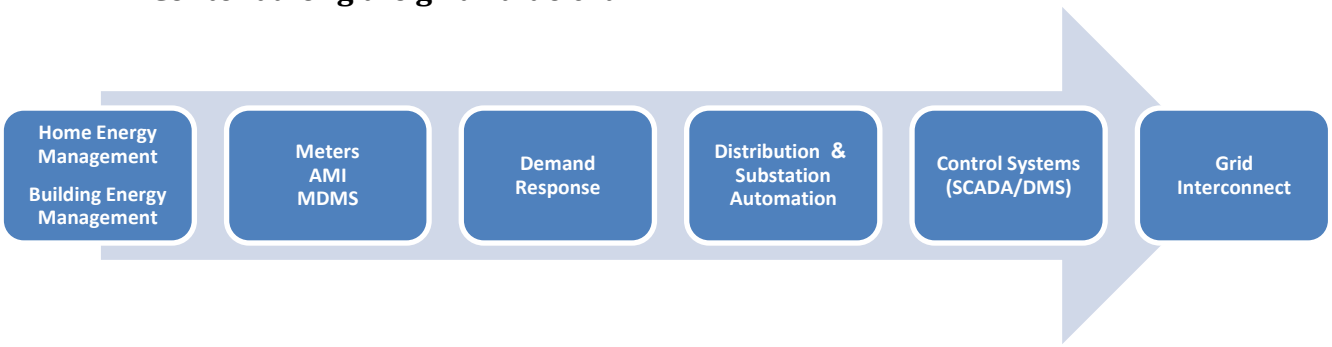
1. Smart Grid review

- **Smart Grid definition**

Bring knowledge to power.

A **smart grid** is a modernized electrical grid that uses information and communications technology to gather and act on information, such as information about the behaviors of suppliers and consumers, in an automated fashion to improve the efficiency, reliability, economics, and sustainability of the production and distribution of electricity.

- **Content along the grid value chain**



- **Smart grid- Goals and priorities**

Smart grid goals may be classified by the following different categories:

- Aggregate level
  - Global
  - National
  - Operators (IEC, Private producers).
  - Customers (Industry, commercial, private).
- Operational level
- Operational/Technical
- Marketing.

Each player has its own different preferences. The point of view of the operator is not necessarily matching to that of the customers, manufactures, service providers and so on. This paper is trying to represent the nation interest. It is

somehow evasive, but it assures optimization of all benefits in favor of the population.

A general statement in line with this objective is: **To transform the electric grid to achieve sustainable energy future for the public good**. ***Smart grid will act as a backbone infrastructure, enabling a suite of new business models, new energy management services and new energy tariff structures.***

The Operational and Technical goals are mainly related to factors as reliability, survivability, efficiency, security, resilience, and have a direct impact on peak demand reduction, decrease of minutes of interruptions, integration of renewable, and reduction of emissions.

The marketing goals has to do mainly with implementation of intelligent real time pricing, reduction of monthly bill payments by controlling electricity consumption and turning the typical energy customer from being passive to being active.

It should be noted that Israel is an electrical island with stand-alone grid. The Smart Grid will allow balancing of power demand and supply.

The following is a detailed list of goals classified by the main stakeholder who benefits the results:

Goals	Categories	Global	National	Operators	Customers
Increase quality of supply – reliability improvement				+	
Ensure system survivability.				+	
Peak demand reduction.			+		
Improve security of energy supply			+		
Ensure operational and energetic efficiency: Decrease average customer minutes of interruptions.					+
Improve control of the distribution system.				+	
Reduction of emissions.		+			
Reduce operational and maintenance cost.				+	
Asset and Resource optimization.			+		
Improve resilience (malicious acts, terrorism, theft, frauds).				+	

Provide self healing.			+	
Integration of renewable energies		+		
Integration of electronic vehicles.		+		
Improve ratio of cost/benefit of energy inputs.			+	
Reduction of electric monthly bill payments.				+
Overall energy consumption reduction.		+		
Accessibility to real time information.		+		
Controlling electricity consumption		+		
Introduction of new services and products.				+
Turning a passive customer into an active one - customer Marketing Energy Management				+
Energy efficiency savings.		+		
Demand site management.			+	
Accurate billing.				+

- **The SG benefits to the energy sector and the national economy**

By optimizing a non-optimized system or a system that was built without long term planning, we can expect a substantial profit. The profit is directly related to the gap between the existing grid situation and the best available technology at the date of implementing.

If we are talking about privatized power market where each power plant is a sole company and the grid is divided by different transmission companies like in the US there is a lot to do at the HV/MV level to create a coherent system, especially where there is interconnections. In Africa the situation is a little bit different where nothing is existing the smart gird need before a gird and then to make it smart. In Israel we have on grid manager and the grid is well managed at the sub-station level and the work will be focused on the domestic/industrial level.

In any case by sharing the power consumption data with the end user and to share the profit by "smart" energy utilization we can expect a real power consumption optimization/profit of 5 to 10%.

For a country having 13 GW installed, it is equivalent to non-building a power station of 1,000 mw equivalent to 1,000,000,000 $ Capex and 1,000,000,000 $ Opex. The associated emission reduction impact is also huge depending on the technology used in the same point of time: gas, coal, renewable etc'…

The side benefit is by having a "smart" control and knowledge of the grid the country will be able to optimize decisions on the next power generation technology and renewable integration.

2. World Trends

- **Regulations**

The regulation is needed in order to fill the gap between the time the smart grid will show the real benefit and the period of investment. This phenomenon is called "CAPEX time-shift problem".
Each country is solving that in different ways and in different incentive levels.
In any case there is no full recovery regulation in any country and this is the main reason that the smart grid integration is suffering of lack of dynamism.
The country that will be able to see the global aspect of the smart grid integration will be the one that may implement the technology in the highest level and consequently get profit of the smart grid sooner that the others.
The monopolistic/centralized aspect of the Israeli power generation and distribution may contribute to the smart grids regulation but on the other hand the bureaucracy can affect this dynamism. The dynamic pricing (as the Taoz) is one of the main booster of the Smart Grid integration at the demand level.
Being oriented in the right manner and due to the fact that Israel did some progress in the right way (at the sub-station and country level) we found that by adopting the right incentive regulation **Israel can be one of the advanced countries in the smart Grid field**.
There is an enormous quantity of data available. The following links will focus the reader in the necessary data to get the whole picture.
The summary of the regulation status in Europe can be found in the following link pages 31 to 39 by countries.
http://www.eurelectric.org/media/25920/eurelectric_report__on_reg_for_sg_final-2011-030-0131-01-e.pdf
The summary of the regulation status in USA can be found in the following link pages 1 to 7 by states.
http://www.eia.gov/analysis/studies/electricity/pdf/smartggrid.pdf

- **Technologies**

The technologies involved in the smart grid solution are:

- ~ Communication
- ~ Information technology - IT
- ~ Demand response
- ~ Meter Data Management - MDM
- ~ Smart metering
- ~ Centralized Grid Management System
- ~ Energy storage
- ~ Security
- ~ Transmission
- ~ Billing
- ~ Load sharing
- ~ Monitoring and Diagnostic Tools
- ~ Sub-station control and automation

- ~ Electrical vehicles
- ~ Smart home and building
- ~ Renewable energies
- ~ Real time data acquisition
- ~ High efficient appliances
- ~ High efficient industrial equipment
- ~ Energy efficiency in industry
- ~ Customer education
- ~ Data Analyzing Tools And Expert Systems

It is important to mention that the main key success of the technology deployment in the smart grid field is the **interoperability** that will allow to all the components to talk one to each other taking in consideration that up to date there is no-one that can give the whole spectrum from in house developed technology.
The **standardization** is also an important factor as well for the successful smart grid integration.

- **Deployments**

Following are some deployment examples.

China: The Chinese government has developed a large, long-term stimulus plan to invest in water systems, rural infrastructures and power grids, including a substantial investment in smart grids. Smart grids are seen as a way to reduce energy consumption, increase the efficiency of the electricity network and manage electricity generation from renewable technologies. China's State Grid Corporation outlined plans in 2010 for a pilot smart grid program that maps out deployment to 2030. Smart grids investments will reach at least USD 96 billion by 2020.

United States: USD 4.5 billion was allocated to grid modernization under the American Recovery Reinvestment Act of 2009, including: USD 3.48 billion for the quick integration of proven technologies into existing electric grids, USD 435 million for regional smart grid demonstrations, and USD 185 million for energy storage and demonstrations.

Italy: Building on the success of the Telegestore project, in 2011 the Italian regulator (Autorità per l'Energia Elettrica ed il Gas) has awarded eight tariff-based funded projects on active medium voltage distribution systems, to demonstrate at-scale advanced network management and automation solutions necessary to integrate distributed generation. The Ministry of Economic Development has also granted over EUR 200 million for demonstration of smart grids features and network modernization in Southern Italian regions.

Japan: The Federation of Electric Power Companies of Japan is developing a smart grid that incorporates solar power generation by 2020 with government investment

of over USD 100 million. The Japanese government has announced a national smart metering initiative and large utilities have announced smart grid programs.

South Korea: The Korean government has launched a USD 65 million pilot programme on Jeju Island in partnership with industry. The pilot consists of a fully integrated smart grid system for 6 000 households, wind farms and four distribution lines. Korea has announced plans to implement smart grids nationwide by 2030.

Spain: In 2008, the government mandated distribution companies to replace existing meters with new smart meters with no additional cost to the customer. The utility Endesa aims to deploy automated meter management to more than 13 million customers on the low voltage network during 5 years, building on past efforts by the Italian utility ENEL. The communication protocol used will be open. The utility Iberdrola will replace 10 million meters.

Germany: The E-Energy funding program has several projects focusing on ICTs for the energy system.

Australia: The Australian government announced the AUD 100 million "Smart Grid, Smart City" initiative in 2009 to deliver a commercial-scale smart grid demonstration project. Additional efforts in the area of renewable energy deployments are resulting in further study on smart grids.

United Kingdom: The energy regulator OFGEM has an initiative called the Registered Power Zone that will encourage distributors to develop and implement innovative solutions to connect distributed generators to the network. OFGEM has set up a Low Carbon Networks fund that will allow up to GPB 500m support to projects that test new technology.

France: The electricity distribution operator ERDF is deploying 300 000 smart meters in a pilot project based on an advanced communication protocol named Linky. If the pilot is deemed a success, ERDF will replace all of its 35 million meters with Linky smart meters from 2012 to 2016.

Brazil: APTEL, a utility association, has been working with the Brazilian government on narrowband power line carrier trials with a social and educational focus. Several utilities are also managing smart grid pilots, including Ampla, a power distributor in Rio de Janeiro State owned by the Spanish utility Endesa, which has been deploying smart meters and secure networks to reduce losses from illegal connections. AES Eletropaulo, a distributor in São Paulo State, has developed a smart grid business plan using the existing fibre-optic backbone. The utility CEMIG has started a smart grid project based on system architecture developed by the IntelliGrid Consortium, an initiative of the California-based Electric Power Research Institute.

Source:
http://www.iea.org/publications/freepublications/publication/smartgrids_roadmap.pdf

- **SG progress by continents.**

In the US, Florida Power & Light completed in April a four-year effort to create what's being considered as one of the largest smart grid projects from home to power plant. Working with GE, the utility installed 4.5 million smart meters and 145 substation upgrades in 35 counties, as part of a program called Energy Smart Florida. The new system helps anticipate disturbances on the grid prevent outages and restore power quickly in a state often hit by destructive hurricanes. The utility can diagnose system problems remotely and make repairs before issues occur. FPL received $200 million in federal stimulus for the project, the maximum granted per utility under the American Recovery and Reinvestment Act of 2009, which initiated several major US smart grid efforts. In all, the US spent about $4.3 billion on smart grid in 2012, according to BNEF.

In the US Northeast, smart grid had a chance to show off its stuff during Superstorm Sandy, a devastating October 2012 storm that knocked out power for weeks or even months for some buildings that were too damaged for immediate reconnection to the grid. Utilities with sophisticated communications networks - the hallmark of smart grid - were able to identify outages on the system more quickly as smart meters signaled trouble back to the utility's central control. "The IT system, the operation system, doesn't put the wire back up in the air, but it tells you where these problems are," said Brad Williams, vice-president for industry strategy at Oracle Utilities, an information technology company that serves several of the large utilities in the Northeast.

In China, Honeywell has completed first smart grid demand response project in the Tianjin Economic-Technological Development Area (TEDA). Honeywell installed automated demand response in commercial, industrial and government facilities, as a way to reduce need on the grid to run expensive peak power plants and cut emissions and costs. The Honeywell technology allows customers create customized energy reduction strategies that utilities put into action when the grid is under strain. The project is part of a joint US-China energy co-operation program helping to advance China's long-term goal of creating a robust, national smart grid by 2020. To that end BNEF says China's investments in smart grid rose 14 per cent in 2012 to $3.2 billion.

In the Netherland's, PowerMatching City Hoogkerk district calls itself as "the first real-life smart grid community in the world" - a kind of living lab initially made up of about two dozen households. Participants use many of the gadgets and appliances

appropriate for smart-grid equipped households: micro combined heat and power systems, hybrid heat pumps, smart meters, PV panels, electric vehicles and charging stations, wind power, and smart household appliances. The homes are meant to demonstrate how we will all use electricity by 2030. DNV KEMA Energy & Sustainability, an energy consulting and testing & certification firm, is leading the initiative.

In Sweden, ABB and the utility Forum are helping the Stockholm Royal Seaport to become an energy-smart district of the future. The goal is to reduce carbon dioxide emissions attributable to each person in the district from 4.5 tons per person to 1.5 tons, as the smart seaport will become a reality through 2030. The project includes a range of energy innovations, from fuelling ships with electric grid power rather than dirtier diesel, to helping homeowners produce 30 per cent of their own electricity through solar and wind energy, and store excess power in electric vehicles. The project focuses on various technologies helping residents become "prosumers" - both consumers and producers of power, who can buy and sell in the energy marketplace. ABB is providing a smart control centre to manage all of these technologies, according to Gary Rackliffe, vice president of smart grids for ABB, a power and automation technology company.

In Australia, the largest electricity network, Ausgrid, is leading a $100 million initiative called Smart Grid, Smart City in Newcastle, Sydney and the Upper Hunter region of New South Wales. The three-year project tests various new energy technologies and pricing schemes with 30 000 households. Ausgrid is experimenting with a range of smart grid devices and approaches from fault-isolating equipment that allows crews to monitor supply remotely to home energy devices, distributed generation, storage, electric vehicles and smart homes. The program is being rolled out through 2013.

In Canada, Ontario has installed small meters for all accounts. About 4.35 million customers were on time-of-use rates as of June 2012. About a dozen companies, among them GE, Siemens and IBM are working on refining smart grid through various province-funded projects. The province is testing in-home energy displays, leveraging data to manage load, advancing grid automation and self-healing, and integrating renewable and electric vehicles.

Ecuador, is the leader among Latin American countries. It released in March 2013 a three-phase smart grid roadmap to 2030. The plan is designed to promote efficiency, adopt new technology and gain better grid awareness and control. Ecuador will install foundational technologies and expand its distribution and transmission over the first four years. The second four-year phase will bring advanced technologies, among them volt and volt-ampere reactive control and

decentralized power. In the third phase, from 2023 to 2030, the country will install micro-grids, advanced load management and other measures.

Source: http://www.powerengineeringint.com/articles/print/volume-21/issue-5/features/more-of-a-journey-than-a-destination.html