A FROST & SULLIVAN EXECUTIVE SUMMARY

Steps Towards a Low Carbon Future: Solutions and Technologies That Will Support the Global Revolution Required



in Collaboration with:

GE Energy

FROST & SULLIVAN

SCOTTISH DEVELOPMENT INTERNATIONAL

Scottish and Southern Energy Power Distribution

SP ENERGY NETWORKS

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Innovative Technology Areas

Active Networks:
It is no longer viable to rely on existing networks that are designed to provide a one-way flow of energy, so in order to maintain power quality, manage assets, reduce maintenance costs, and maximize reliability, network operators are evolving their management systems

Distributed Energy Resources:
A key low carbon enabler is the use of distributed renewable and storable energy resources, which includes the efficient integration and accelerated delivery of new energy sources

Demand Response:
Addresses the management and movement of network load and consumer demand, which is achieved through smart technologies such as Smart Meters and smart appliances to provide consumers with choice in collaboration with energy suppliers

Network Monitoring:
Because network assets are expensive to replace, improving network visibility of metrics and performance is crucial; monitoring activities will improve long term asset management, capital investment plans, as well as optimize network performance

"Over the course of the next ten years demand for electricity is going to far exceed the supply by three times."

As the existing Electric Grid moves toward clean energy, a smart grid will become essential to controlling the flow of energy from power companies to the consumer.

Meanwhile, the demand for electricity continues to grow across the globe at an alarming rate. It is estimated that the demand for electricity will far exceed the supply in the next ten years. At the same time, the inability of the current electric grid to store energy is creating huge gaps and inefficiencies that need to be answered.

"Solving demand by merely building more power plants is no longer an option. Instead, the emphasis is on generating cleaner power as well as using less power altogether," said Farah Saeed, Principal Consultant at Frost & Sullivan.

Emphasis is now being placed on generating cleaner, newer power, and on increasing the accountability and rewards for good behavior.

A Safe, Effective Way Toward a Low Carbon Future

Grid modernization, or smart grid, takes a close look at the electric grid and finds ways to make power flow more efficient and reliable. "Power efficiency and availability are among the key concerns for many utilities, especially as they're faced with pressure to accommodate renewable power as well as the growing use of electricity," said Saeed.

The existing power grid transports energy from the power station to the consumer through three sources. Because the existing grid cannot store energy, the energy loss from power generation to power transmission to power distribution to the consumer is substantial. Grid modernization would not only minimize these losses but also bring the consumer closer to the power generation source.

Frost & Sullivan Insight on Smart Grid Technologies:

Smart grid is a strategy that aims at automating, improving, and increasing the availability and efficiency of the electric grid that ranges from generation to transmission systems as well as to distribution levels – from power generation to the consumer. There are a multitude of technologies looking to solve these problems. Utilities are facing increased pressure to not only make the electric grid more efficient but also able to support the transmission of power from renewable energy sources, but no two utilities share all of the same problems when looking to upgrade their grids. Fortunately, some similar strategies do exist. These strategies include:

- **Advanced Meter Infrastructure:** Looks at the smart meters and communication infrastructure, which enable a two-way communication stream between the end user and the utility. AMI allows for both parties to make smart decisions about energy consumption and supply.
- **Demand Response:** Provides actual incentives for the end user to curtail power consumption. Demand response is also referred to as Power Containment Programs. Programs such as direct load control and economic pricing combined with smart home appliances, smart meters, and home automation, can determine precisely what kind of saving to expect at a given time.
- **Distribution Grid Management:** Consists of distribution automation, substation automation and integration, in addition to field equipment.
- **High Voltage Transmission:** Comprises flexible AC transmission systems (FACTS) as well as high and ultra-high voltage DC (HVDC) and grid monitoring systems that are all being used to monitor transmission lines.

Global Smart Grid Performance

A great deal of investment has already been made into using smart grids across the globe. Frost & Sullivan has found that annual sales on the global smart grid have been about $23.97 billion in 2010. Projections for 2012 are almost $41 billion dollars globally.

In North America there has been a 20% penetration rate of smart meters and is expected to reach 50% within the next five years.

In Europe, the energy package directed by EU member states aims for 80% of consumers

Case Study

How to manage the consistency and balance of low carbon electricity supply?

- Active Network Management System: Allowed Scotland to connect about 12MW of additional wind power for about 1/60th of the cost of conventional reinforcement which was designed through Scottish companies.
- Nines Project: A £30 million project has 150MW hours worth of energy storage in the form of batteries and heat storage; its success shows how a balance can be made to get renewable energy onto the system.

Smart Grid Evolution:

- The Nines Project is expected to lead to an increase in voltage upgrades, the construction of off-shore wind energy projects, and new imbedded HDVC interconnectors, as well as the installation of control logic technology to minimize the losses and help to maximize the HDVC plant.
- The Power Network Demonstration Center will maximize the thermal capacity in the system using meteorological data from weather stations; all of the technologies that will be utilized are part of the Smart Transmission Zone Concept

Grid Modernization is Driven by…

The factors driving the adoption of smart grid technologies comprise a range of different issues. Chief among them is getting the regulatory approval and funds to increase the efficiencies needed to modernize the grid.

to use electric smart meters by the year 2020. This equates to the replacement of 145 million meters across Europe.

And in the UK, the department of energy has enacted regulation that mandates nationwide AMI. This plan involves replacing 47 million domestic meters, gas and electric, across all 26 million homes nationwide by the year 2020.

Despite these success stories throughout the US and Europe, the industry has a lot to overcome with plenty of room for new and improved solutions. To succeed, the industry "requires advancements for senior technologies, software applications, and analytics, as well as communication systems," said Saeed.

Looking toward the future, utilities and technology providers are currently discussing the interoperability and integration of all of the systems needed to modernize the grid. This integration is vital.

But a question remains: How do we fully guarantee a successful transition to smart grid?

Case Study – Scotland

Despite being a small country, Scotland is competitive and collaborates with universities and companies to find low carbon technology solutions. In addition to its government support, networks, and infrastructure, the country leverages excellence in academia as well as research and development initiatives.

Scotland also boasts skilled workers, trained at its prestigious universities, and a long history of excellence in energy and engineering.

Perhaps most importantly, Scotland also offers financial incentives for investment in low carbon technology.

Building a Next Gen Smart Grid in Scotland

Scotland has already been working to develop the next generation of smart grid technologies. The country has a vested interest in smart grid and grid modernization, as well as ambitious goals to modernize its grid. The country wants to harness its resources and achieve a low carbon future for itself – as well as for the globe. "The level of opportunity in Scotland is measured by the level of ambition we have and the targets we have set ourselves," said Allan Currie, Director of Scottish Development International.

These targets are considerable and well worth noting. Scotland has plans to reduce its carbon emissions by 42% by the year 2020 and then by 80% by 2050. Additionally, Scotland expects to generate 80% of its electricity from renewable sources within the next ten years. Its target is to be 100% generating renewable energy by 2020.

Already the country has managed to reduce carbon emissions by 21% and is generating 22% of its energy from renewable sources.

Scotland now strives to grow smart grid into a £20 million industry by the year 2016 which would translate to 130 thousand jobs as well as represent 10% of the country's GDP.

"So the challenge we have is to harvest and harness the potential we have for renewable energy generation in a way that helps us meet these targets but does so in a way that provides an energy resource for our nation," said Currie.

Key Issues Affecting Low Carbon Investors

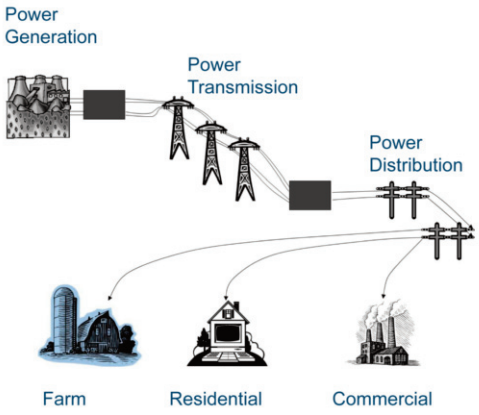
While low carbon technologies have the potential to make contributions to the achievement of the EU's carbon emission and energy saving targets, there needs to be a connection or mechanism between the social benefits of working on a project to the party that bears the cost.

Potential Solutions:

- Finance to support commercial skill demonstrations, regulate size of capital expenditure, and increase rate of return
- Infrastructure to streamline the planning process to incentivize new grid connections and the transmission and distribution of investments

Regulation, which is the moving away from rewarding cap expend to rewarding other criteria such as efficiency and sustainability

The Electric Grid



- Electricity cannot be stored; therefore, production is adjusted according to demand.
- Electricity is transmitted in stages, referred to as power transmission and power distribution.
- To minimize line losses, voltage is increased to more than 69 kilovolts by power transformers when it leaves a power plant. This stage is referred to as power transmission.
- Step-down transformers lower the voltage once power is close to its final destination so that it can be distributed at a lower voltage of 415/230 volts. This stage is referred to as power distribution.

"By that I mean a consistent, reliable, and uninterrupted supply."

To that end, the resources that Scotland can harvest and harness include a variety of renewable energy sources such as hydro, biomass, and solar energies, as well as wind energy, which makes up 25% of Europe's overall wind supply. This creates a rich mix of energy that has potential but also the challenge to manage a variety of energy sources that are harnessed using different technologies in an efficient and effective manner.

In addition, Scotland has expertise in areas such as sensor, smart grid, and wireless technology, which will lead to the effective analysis and management of required distribution networks.

Consequent to these efforts, Scotland is offering many incentives to meet its futurereaching carbon goals and take advantage of its existing resources. These incentives include:

- **National Renewable Infrastructure Fund (NRIF):** Offers £17 million over the next three years for enhancing the infrastructure around Scottish ports to support manufacturing of offshore wind turbines and related components in addition to developing test and demonstration facilities.
- **International Renewable Zone (ITREZ):** A £100 million project that will transform Glasgow's city center into an area for research and development and design the next generation of offshore marine renewable and associated technologies.
- **Power Network Demonstration Center:** This collaboration between private entities and academia is looking to overcome technical barriers for adapting smart grid technologies and will focus on the integration of renewable energy sources, electric vehicles, and smart household appliances. It will be supported by the Scottish Enterprise and the Scottish Funding Council in collaboration with the University of Strathclyde, ScottishPower, and Scottish and Southern Energy.

Informatics Research in Scotland:

In regards to demonstrating actual movement on smart grid technologies to modernize the electric grid, Scotland benefits from a substantial research knowledge base located within a tight geographic area.

"We have a critical mass and a very wide range of skills and approaches that can be tapped into from academia," said Colin Adams, Director of Commercialization at the School of Informatics at the University of Edinburgh.

Crucial to the success of Scotland's renewable energy and technology initiatives is the Scottish Informatics & Computer Science Alliance (SICSA), which is a consortium of thirteen Scottish Universities that are experts in the field.

SICSA includes the School of Informatics in Edinburgh. The universities focus their research on the modeling and abstraction of complex data systems, the engineering of complex infrastructure, as well as next generation internet, and multimodal interaction.

"SICSA allows companies to interact essentially through a single shop with a range of universities rather than having to split up arrangements separately with them all," said Adams.

Many of the technologies being researched by SICSA are directly relevant to smart grid.

Global Smart Grid Market Performance

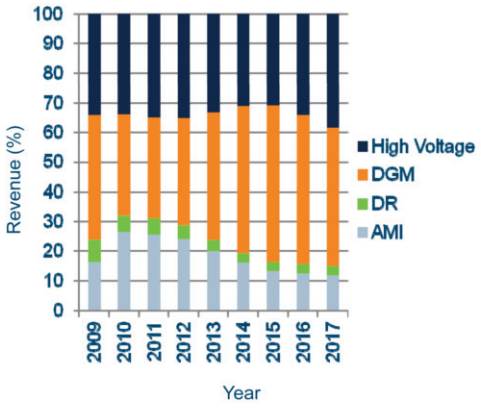
Frost & Sullivan research estimates the global smart grid market to have been about $23.97 billion in 2010.

The market is projected to grow at CAGR of 26.6 percent between 2010 and 2017.

Distribution grid management (DGM) held a dominant position in 2010.

By 2017, DGM is expected to remain the largest smart grid product segment. This is being driven by initiatives to mitigate and reduce power interruptions, improve power management, as well as improve utilization of existing resources.

Smart Grid Market: Percent of Revenue by Technology (Global), 2009-2017



Note: All figures are rounded. The base year is 2010. Source: Frost & Sullivan analysis.

These technologies comprise:

- **Big Data Analytics:** Allows the extraction of more information from the large amount of data that is picked up from the grid
  - **Computational Modeling:** The ways in which researchers reason and interpret the data that is picked up
  - **Machine Learning:** Picking out trends as well as utilizing database technology
- **Complex System Engineering:** Developing a reliable infrastructure
  - **Autonomics:** Self-managed systems
  - **Socio-technical Systems Engineering:** The technical aspects of deploying new systems
- **Wireless Sensor Networks:** Gives the ability to connect the customer with the producers and the smart devices

Implementing Scotland's Forecasted Renewable Energy Growth

In order to enable the existing network in Scotland to accommodate the forecasted growth in renewable energy generation, the country has already begun to carry out upgrades and technology overhauls.

"There are many things we're looking to carry out at ScottishPower and in fact have already started to carry out," said Jamie McWilliam, Technology Manager, ScottishPower EnergyNetworks.

Upgrades to ScottishPower's smart transmission concept include: better monitoring devices on the transmission lines and control logic to minimize the energy losses, as well as meteorological software used to monitor the generation of wind power. Low voltage networks are also necessary to evolve.

ScottishPower is working together with SICSA on a power generation center to test and develop these new technologies – including automation gear.

"At ScottishPower we are developing low voltage automation so that we can remotely operate and monitor our network in ways we've not been able to in the past," said McWilliam.

Concluding Thoughts

As seen in Scotland, it is important to choose solutions that are sustainable. The smart grid is about enabling sustainable solutions to be connected to the network that will break that additional linkage between growth and the break down of sustainability in our world.

With the global smart grid market at $23.97 billion in 2010, Frost & Sullivan research forecasts the market growing by 26.6% between 2010 and 2017.

Low carbon technologies are now available for investment and can increase a company's energy efficiency. The technologies to look toward implementing are those that reduce energy losses to more efficiently transport electricity across the network.

Network modification tools are also a source of interest as are many forms of clean energy generation and new forms of energy storage, such as hydrogen, wind, and hot water storage.

Looking at the issue from a higher level, there is a need for improved power quality in the digital age, which thusly opens another area for investment.

As smart grid suggests, rather than over sizing your network, storing energy is a more sustainable goal to lower carbon emissions and lead us into the future.

About Scottish Development International

SDI aims to assist in the growth of the Scottish economy, by encouraging inward investment and helping Scottish-based companies develop international trade.
A joint venture between the Scottish Government, Scottish Enterprise and Highlands and Islands Enterprise Scottish Development International brings together the resources of these organisations to deliver support for companies investing in Scotland. Learn more at www.sdi.co.uk

About Scottish & Southern Energy Power Distribution

SSE is a FTSE 100 company and one of the largest and most respected energy companies in the UK. As well as being involved in the generation, transmission, distribution and supply of electricity, SSE has interests in energy trading, energy services, gas storage, the distribution and supply of gas, electrical and utility contracting and telecoms. Learn more at www.ssepd.co.uk

About The University of Edinburgh, School of Informatics

Over recent years the School of Informatics has undergone a rapid expansion in research capacity. By working closely with industry, the business community and Government partners this cutting edge research is having a significant impact on the Scottish and Global economy.
The dedicated Commercialisation and Knowledge Transfer team work within the School's individual research institutes to foster improved links with industry, assist with the commercialisation of research undertaken and help build entrepreneurial programmes. Learn more at www.ed.ac.uk/schools-departments/informatics

About ScottishPower EnergyNetworks

SP Energy Networks own and operate the electricity transmission and distribution network in the south of Scotland and the distribution network in Cheshire, Merseyside and North Wales.
As the network operator SP Energy Networks maintains and repairs the electrical equipment and network assets that transport electricity to around 3.5 million homes and business. Learn more at www.spenergynetworks.com

About GE Energy

The Digital Energy business within GE Energy provides integrated smart grid solutions and reliable power delivery systems to electric utilities as well as the oil & gas, critical infrastructure and industrial sectors.
Smart grid is the marriage of information and automation technologies with our electrical infrastructure to support our 21st Century global energy needs… enabling us to do more with less through increased efficiencies. Learn more at www.gedigitalenergy.com

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This Executive Summary discusses key insights and excerpts from a live presentation and panel discussion by Frost & Sullivan, Scottish Development International, Scottish & Southern Energy Power Distribution, The University of Edinburgh, School of Informatics, ScottishPower EnergyNetworks, and GE Energy on February 9, 2012. This summary presents industry insights, best practices, and case studies discussed by the presenters, in the context of the live presentation and panel discussion. For more details, visit http://www.frost.com/carbon. Frost & Sullivan is not responsible for the loss of original context or the accuracy of the information presented by the participating companies.