Global Energy Exchange - Data Without Borders

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ABSTRACT

For harmonisation of data, models are absolutely essential, enabling more automated, more change enabled, flexible and future proof technology. A model led implementation of energy transmission data is an effective way to ensure a standard approach to energy monitoring & marketing, and Sparx Enterprise Architect hosts the Utilities Common Information Model.

Being able to generate messages about electricity supply and energy markets using a combination of code and data generation from an enterprise model linked to the Utilities CIM, an OMG DDS implementation, and standard geospatial models is an efficient way to deliver large volumes of energy data messages about supply, and markets across networks, with cloud technology.

Interoperability is, after all, the holy grail of Smart Grid.

The deployment of real-time Smart Grid operations can provide information flow about energy supply and demand amongst end-users, electricity generators, and the electricity grid. Most countries are upgrading their transmission and distribution networks to be ‘Smart Grids’, with data from SCADA, OMS and EMS systems, and increasingly from the next generation Wide Area Measurement Systems (WAMS). This represents a unique opportunity to provide real-time geospatially connected data for a wide range of metrics and calculations from power generation, transmission and distribution, including energy and carbon trading, associated greenhouse gas emissions, and energy efficiency savings.

New technology initiatives can be very costly, with long lead times, and significant lag times for

implementing change. Smart Grid costs can be significantly reduced, and flexibility can be significantly increased by sharing technology deployments.

As the energy industry landscape is transformed, there is an urgent requirement to standardise the format of data able to exchange information for electricity and transport consumption and markets. There is no reason that there cannot be global harmonisation of energy data exchange.

The Utilities CIM is an abstract UML model that provides coverage for data elements in the Utilities industry, objective, informational, and enumerative. It can be extended to cover Wide Area Management, and synchrophasor metrics.

Today's ICT technology is increasingly automated from UML models. Connections between a model of physical elements, such as the CIM energy management and electricity supply domain, with common ICT technology, such as messaging and analytics. This gap means that significant costs and complexity of implementation effort has to be incurred to for further Smart Grid automation, with web workflows, data integration, event processing, data centric messaging etc.

To decrease risk, there has to be an increase in the accuracy of human, machine, and financial resource estimates, for an ICT enabled Smart Grid. A standard interoperability metamodel can provide a global context for information delivery. Exchange of energy management and market data is key to managing energy supply efficiencies across network operator regional boundaries.

Energy data exchange can be affected by current, best practice ICT technology, built from a platform independent metamodel, to bridge the gap between energy metrics, realtime decisioning, and energy market data flows.

A common model can provide the bedrock for the algorithms and definitions required to synchronise real-time metrics. Data models (such as the Utilities CIM), can provide the reference metadata for interface mappings in a real time geospatial context.

Model-led deployment of technology to provide energy data and information technology workflows, can deliver supply and demand efficiencies for both energy and carbon trading, across time zones and national boundaries, by reducing the costs of integration, because of harmonised data elements.

Synchronisation of data definitions, through adherence to a specific model can optimise technology services by simplifying the number and scope of systems interfaces .

For each network operator, interoperability of data can be faciilitated by translation into common formats from web interfaces and workflows for automated mapping.

Geospatial information, and harmonisation of data and standards, plays a fundamental part in addressing semantic information flows. Location can provide a key to referencing metadata.

A location centric repository can provide a register for network assets, as well as data structures, transformation algorithms and messaging subscriptions.

To connect energy management and market models and geospatial models, in an information delivery context, enables operational and business intelligence from Smart Grid network devices to be mapped geographically.

Energy geospatial overlays provide an opportunity for utilisation of CEN/ISO/OGC standards, and emerging geospatial practice, further enabling data exchange among relevant energy stakeholder groups, able to share network and market intelligence without delay. Correctly implemented, operational intelligence, geographically mapped, can become widely accessible, simplifying and clarifying the processes of energy and carbon trading across borders, for current players, as well as the increasing numbers of renewable energy generators.

In addition to well publicised areas such as energy efficiency, grid health, and demand management, one aspect of the energy industry transformation that cannot be overlooked, is the potential to collect accurate data for monitoring the world's CO2 emissions from electricity consumption. Improvements can be made in the quality of the energy data to which carbon emission monitoring algorithms are applied.

Energy supply and demand efficiency must accommodate distributed, renewable energy generation - not only from new renewable energy generation plants, but also industry and households. This means that real-time supply and demand data access will be a critical factor to enable energy efficiency by transmission and distribution network operators. To meet the threat of a world energy crisis, operational processes have to be fully automated, based on real-time energy information made accessible across national boundaries to meet the information requirements of all stakeholder groups.

INTRODUCTION

Regional, national, and international energy markets are challenged by the inclusion of large scale renewable energy sources into the grid. Accelerating consumer supply and demand also stress the ability of the current infrastructure to meet future energy needs. Accuracy can be improved by utilising Smart Grid operational data collected in real-time, as these new challenges have a temporal urgency, in view of UN IPCC climate change reports.

The best way to proceed is to start with standards that are already in place, then extend them to provide a common terminology, not only for energy efficiency, but also energy and carbon trading markets. This represents a real paradigm shift in current thinking and practice.

Smart Grid interoperability cannot be defined simply by a data model and web services. It has to be demonstrated in the context of a cross-border energy exchange of high speed, real-time metrics.

The breadth of application of synchrophasor technology can be not only for network stability monitoring and demand management, but also for post event analysis. Smart computing devices attached to ICT networks can provide pre-processing of energy transmission data not only to energy management processing systems, but also to energy market technology systems.

Fossil fuel and renewable energy source metrics are important variables in carbon trading, as well as pricing in energy markets. Geospatial analysis of energy utilisation, pricing, and CO_2e emissions reduction insight can be made accessible from post event analysis of real-time data.

This information is of interest, not only to energy industry stakeholders and governments, but also to industry and households, as everybody has to participate in energy efficiency, supply and demand, and carbon emissions reduction, to achieve climate change mitigation.

To integrate energy information, with geospatial infrastructure, means being able to integrate geographically diverse information from both electricity and ICT networks, efficiently and successfully. This is only possible if the industry has a common parlance for automated data distribution, and workflow synchronised, and authorised collaboration and co-operation for sharing energy intelligence across organisation and national boundaries.

Smart Grid and ICT operations platforms can provide cost-effective energy efficiency, and energy pricing data, in a geospatial context, as well as carbon emissions reduction metrics. In fact this is essential to meeting the new situation of wide area energy transmission, consumer energy generation, and CO_2 reduction targets.

Time is running out for addressing global energy financial and environmental costs. To proceed, it is critical that there is no tower of Babel. Now is the time to decide on common standards and terminologies. And even more importantly, now is the time to recognise that an efficient and effective technology for an automated energy data exchange as to be an international collaboration.

The core ICT technology required to mobilise a cost-effective Smart Grid, is a common semantics-based energy data integration of complex event and web content delivery technology, data centric high speed distributed, real-time information access.

Agreement on semantics cannot be the province of standards bodies only. It is too complex for theoretical approaches to produce a completely useful set of semantics. Semantics have to be developed by application of best practice technology in a pilot phase.
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Standards based Smart Grid/ICT can be agreed by upon by Energy and ICT stakeholders to develop a common energy model exchange technology approach.
In view of the EU's "An Energy Policy for Europe", the North Sea SuperGrid, and the fact that industrial energy utilisation currently accounts for the majority of all global greenhouse gas emissions.

There are any number of approaches to providing ICT solutions to integrate Smart Grid information with geospatial and organisation data for operational, business and market purposes. If these solutions are not synchronised, there can be no effective information exchange across regional boundaries.

An efficient and cost effective solution has to discover, test and automate a common exchange model as the basis for generation of Smart Grid events triggering post event analysis workflows and transactions for an interconnected energy market.

Historically, excessive ICT costs have been incurred by information gathering from semantically incompatible data.
The characteristics of technology effecting a common exchange of data based on common models has to be
1. Able to connect different technologies across Smart Grid and ICT in real time
2. Able to be easily deployed on current technology integration platforms, networks and infrastructure clouds
3. Able to use and translate to and from common vocabularies and protocols.
4. Able to access and utilise standard geospatial data overlays and infrastructure

Background

According to the European Union's "An energy policy for Europe" legislation [1], energy accounts for 80% of all greenhouse gas emissions in the EU, one of the acknowledged factors contributing to the development of the current energy policy.

The amendment to regulation (EC) No 1228/2003 on conditions for access to the network for cross-border exchanges in electricity, on conditions for access to the network for cross-border exchanges in electricity, is changing the nature of Energy Transmission. Part of European energy policy is the role of ICT (Information, and Communication Technologies) to facilitate the transition to an energy-efficient, low-carbon economy.

US Department of Energy's website endorsement of the "National Transmission Grid Study", part of which is "Ensuring the Timely Introduction of Advanced Technologies" [2] , promotes the modernizing of America's electricity infrastructure, and is one of the U.S. Department of Energy's top priorities.

The NIST (National Institute of Standards and Technology) website US Recovery Act information has targeted funding in the area of energy, environment and climate change. Named sub topics include - Research on measurement technologies to accelerate the deployment of Smart Grid to the US electric power system. - Research to develop advanced measurement capabilities to monitor greenhouse gas emissions. [3] Innovations in Energy storage technologies [4] , the European North Sea renewable SuperGrid [5], and the European Commission Energy target '20% renewable energy by 2020" [6] has dramatically increase the significance to transmission network operators of Smart Grid and associated ICT technologies to include renewable energy generation on a large scale.

To accommodate these developments, it is essential to deploy Smart Grid operational event data, geospatially connected by common semantics, standards-based and interoperable ICT technologies. Standards, Protocols and Terminologies The work of the CEN/TC (European Committee for Standardization: Technical Committees) [7], number 287, has ensured that there is interoperability between the ISO[8], OGC [9] and Inspire [10] geospatial data and frameworks. ICT industry not-for-profit consortium, the Object Management Group, has developed an approach, known as Model Driven Architecture (MDA) [11] supported by the Universal Modelling Language (UML) specification [12] , to help automate and integrate information across diverse formats, applications and technology platforms.

The Telecommunications Shared Information and Data model (SID) [13] is an industry model that has been constructed with deployment in mind. The Utilities CIM, incorporating the IEC standards 61970 and 61968 [14] is a UML 2.1 Platform Independent Model to describe the current state of Energy Generation, Transmission and Distribution - "Unlike a protocol standard, the common information model (CIM) is an abstract model that may be used as a reference, a category scheme of labels (data names) and applied meanings of data definitions, database design, and a definition of the structure and vocabulary of message schemas. The CIM also includes a set of services for exchanging data called the Generic Interface Definition (GID)." The GID specifies how to exchange data, while the RDF CIM is an XML version of the model, useful for system interaction. Both are designed to facilitate information exchange between Smart Grid and ICT technologies.

The OMG DAF (Data Access Facility) Specification[15], designed to address Utility Management Systems, mobilises the RDF version of the CIM. The OMG DDS (Data Distribution Service), and DDSI (Data Distribution Service Interoperability) Specifications [16] provide for a distributed global data space for high speed messaging and semantic interoperability over a wired network protocol. A geospatial context for Energy Smart Grid data is essential to take advantage of technology advances such as WAMS ….. "In Europe, the SmartGrids initiative is developing a roadmap to deploy the electricity networks of the future, and WAMS is one of the key technologies considered. In the U.S., the Electric Power Research Institute (EPRI) runs an initiative aiming to provide a technical foundation to enable massive deployment of such concepts (Intelligrid)" [17]

The European Commission geospatial standard INSPIRE [18], provides not only geospatial data and infrastructure, but also a community geoportal is currently being developed, to provide real-time geospatial context.

What is required is a simple standard way to deploy the energy models such as the Utilities CIM in a geographically distributed Long Term Evolution ICT network context, with automatic semantic translation, on a technology platform capable of high speed complex event processing, to meet the current legislative, operational, business and market challenges for Trans European Energy Networks. This interoperability standard has to apply to the performance of the integration technology, as well as the common data service domains, keys and topics for energy management and market data.

ICT Advances

New ICT paradigms have emerged in recent years, including "cloud" infrastructure grids, automated semantic data, web federated and low latency real-time messaging services, smarter wireless devices, next generation IP networking, federated web content delivery and complex event processing.

The context over the next five years is rapid development and growth in Energy Smart Grid technology, renewable power sources, energy trading, and the linking of real-time grid data into the carbon trading market. These radical transformations will be accelerated by consumer participation in energy supply and demand, and new legislative requirements for energy efficiency, carbon and energy markets.

What is required to meet this growth, is a semantic core technology that supports the current and emerging standards of high speed event technology automation, able to connect with a huge diversity of new and existing Smart Grid and ICT technology, and very importantly, supports the existing and emerging ICT standards relevant to Energy Generation, Transmission and Distribution. At this stage, there is a type of modeling technology that supports this architecture, and that is UML integrated Model Driven Generation (MDG) Platform Independent Modeling, supporting standards in architecture, business process automation, and systems engineering, event processing and data distribution. However there are few players in this space, and even fewer supporting the particular requirements for an Energy Model Exchange technology.

UML is the defacto standard used by most technology suppliers to deploy business workflow, web information access, real-time complex event handling, and data and message integration on a distributed technology grid, governed by current and emerging Energy and ICT standards, and models.

Developing Smart Grid ICT Interoperability

Energy exchange model technology requires a complete a UML/MDG automation into a high speed event context. Data exchange has to encompass and automate not only energy data elements, but also new energy efficiency and trading, and carbon trading semantics that are only now being identified. A metamodel has to be a Smart Grid/ICT deployable exchange model that is more than just the canonical model of energy elements, that , for example, the Utilities CIM provides.

The technology has to provide for ICT data distribution and event handling services metadata, as well as additional semantics for energy trading, efficiency, and CO2 emissions. This metamodel has to be able to logically connect all elements from Smart Grid and ICT deployment in a real-time network context.

This marks the real challenge for interoperability of existing utilities ICT systems, e.g. load management, transmission and distribution, metering and billing applications, with new energy intelligence, including demand management, energy efficiency and trading markets.

The timeframe, to meet with EU Energy policy and legislation directives about renewable and sustainable energy, energy efficiency, security of supply, as well as technology and innovation, is quite short .

Evaluation

Efficient, geospatially aware energy management requires model technology automation of high speed real-time event handling in a multi-party semantic communication framework in the context of distributed, allocate-to-order real-time infrastructure performance. An energy model exchange technology has to go to the next stage of automation evolution. It has to presume a multi-way teleportal communications paradigm shift, with all parties as energy suppliers, and all parties as energy consumers, to facilitate energy and carbon markets.

The energy Smart Grid also has to meet many of the ICT challenges of IP V6 Long Term Evolution networks, requiring an advanced flexibility and growth capability, able to connect and upgrade smart telemetry device interactions, capable of adding new functionality without redevelopment.

What is required to meet these challenges, is a distributed, model-led, semantic, integration capability based on a deployable common geospatially aware exchange model that connects the elements of the CIM, databases, web services, and messages. And these characteristics have to be put to work in the energy Smart Grid context of complex operational event processing, business integration services, deployed on scalable network and server infrastructure. In addition, information has to be accessed and exchanged by different stakeholder groups, organisations and businesses across Europe.

Technology is Deployment Ready

There are already interface, communications and data standards and infrastructure, developed by various global standards organisations, an energy
model exchange technology can readily be achieved with a collaborative, concerted effort by Energy and ICT stakeholder organizations.

In terms of finding a modeling technology capable of meeting the trans Europe energy challenge, Sparx Systems technology is a leader in the support for open technology standards and semantics, particularly those standards that would enable a high speed Energy Model Exchange, with existing support for the Utilities CIM, as well as OMG MDA and DDS.

Geospatial Awareness

Standardisation of geospatial information and infrastructure is a significant advance for the cause of interoperability in Energy Smart Grid/ ICT. It is important for energy artefacts to be included as standard overlays with the Inspire, ISO and OGC initiatives. The next step is to ensure that geospatial data is integrated via the common semantic data exchange outlined above. Geospatial integration raises the subject of distributed data processing, able to provide global geospatial context with local maps and information.

Conclusion

An energy model exchange technology, developed collaboratively, amongst stakeholders, is a cost effective way to deploy an evolving Energy Smart Grid.
Most importantly, an extension to the Utilities CIM could provide standard interfaces to realtime energy data, to provide cross domain operational and business metrics that currently do not exist. This would allow carbon emissions monitoring algorithms for the estimation of greenhouse gas emissions avoided by electricity generation and efficiency projects, to be shared across the industry, for emissions trading schemes, consumer pricing incentives, etc.

Last, but not least, data inaccuracy puts downward pressure on price in carbon markets. Current estimation techniques and algorithms may be improved by gathering sample data electricity networks pilots. Data can be aggregated to provide emissions from energy generation by generator type on a near real time basis. Energy market data can also benefit by virtue of the fact that emissions trading data produced by energy exchange technology can be extended to provide automated transaction updates across geographic and national boundaries in real-time.

Once a real-time trading market on greenhouse gas futures from electricity transmission has been established, it is a fairly short path to collecting data for transport fuels, and then industrial processes, given the work done by the Intergovernmental Panel on Climate Change to develop accurate emissions calculations algorithms.

A pilot project for electricity transmission and market data from renewable energy sources is an obvious starting point.

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