ESB - EPRI Smart Grid Demonstration Project

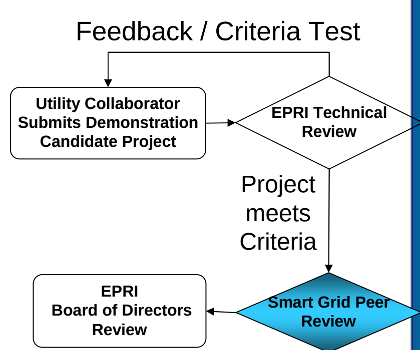
Anthony Walsh ESB Networks

PNM, Albuquerque, 13th Oct 2009

EPRI Smart Grid Demo Peer Review ESB "Host-Site" Project

EPRI Smart Grid Demonstration Peer Review Web-cast

- Purpose:
  - Share project with Collaborators & Peer Review Team
  - Get Feedback from members & peer review team (Sanity Check)
- ESB's proposal has gone through EPRI's Technical Review
- Currently 5 Smart Grid "Host-Site" demonstration Projects



ESB NETWORKS

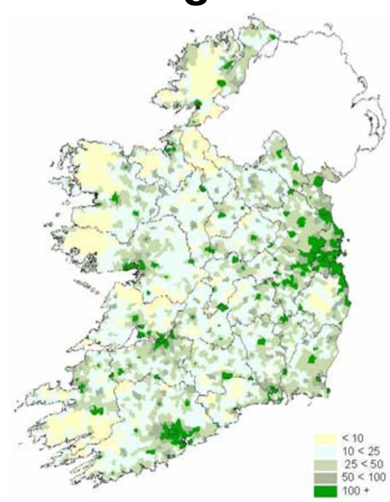
ESB - EPRI Smart Grid Demonstration Project

Anthony Walsh

Republic of Ireland – Background

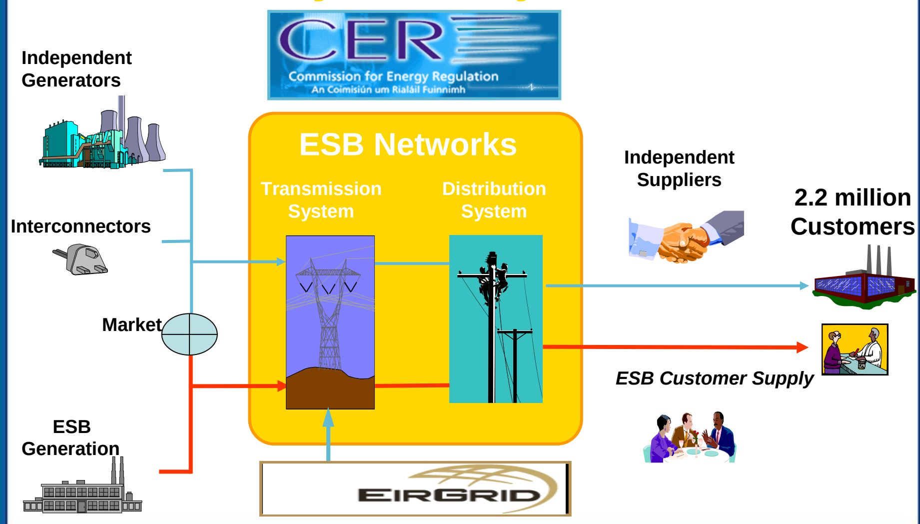
ESB Group:

- **€ 8b assets ; ESBN €5b**
- **€ 3.5b turnover (2008), € 0.3b Net Profit**
- **2,2m Electricity Customers**
  - **Population 4 M - 40% live in countryside Area: 70,000 km2**
  - **Total GWh 23GWh - 5,500kWh pa /Domestic Customer**
  - **System Peak: 5,035 MW**
- **ESB Employees 7,900; ESBN 3,500**



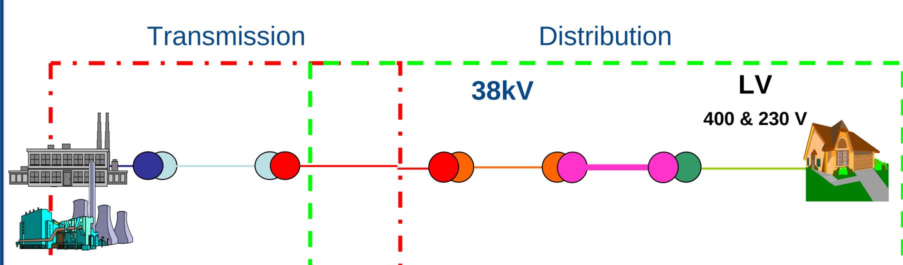
Networks
www.esb.ie/esbnetworks

Electricity Industry Structure…



Networks www.esb.ie/esbnetworks

Network Assets



Transmission
- 6,300 km of Overhead Network
- 140 km of Underground Cables
- 165 HV Stations

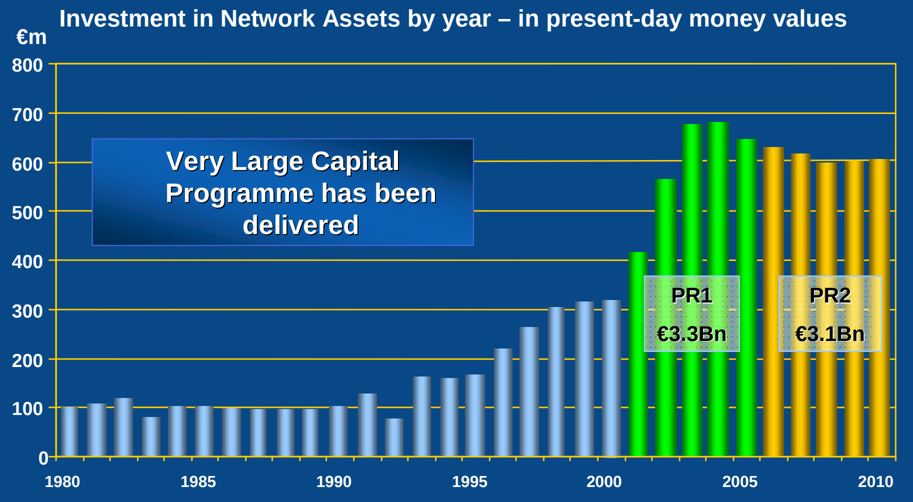
€1b RAB Value

Distribution
- 140,000 km of OH Lines
- 19,000 km of UG Cables
- 630 HV Substations
- 230,000 MV Transformers/Units
- 2m meters

€5b RAB Value

Networks www.esb.ie/esbnetworks

PR2 - Infrastructure Investment



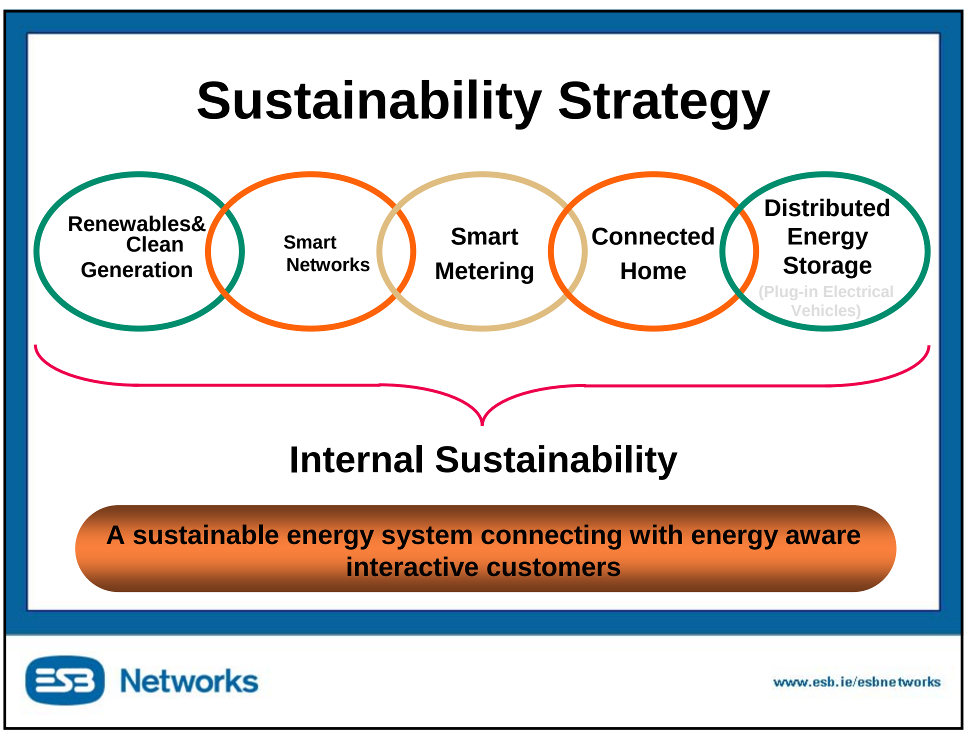
Networks

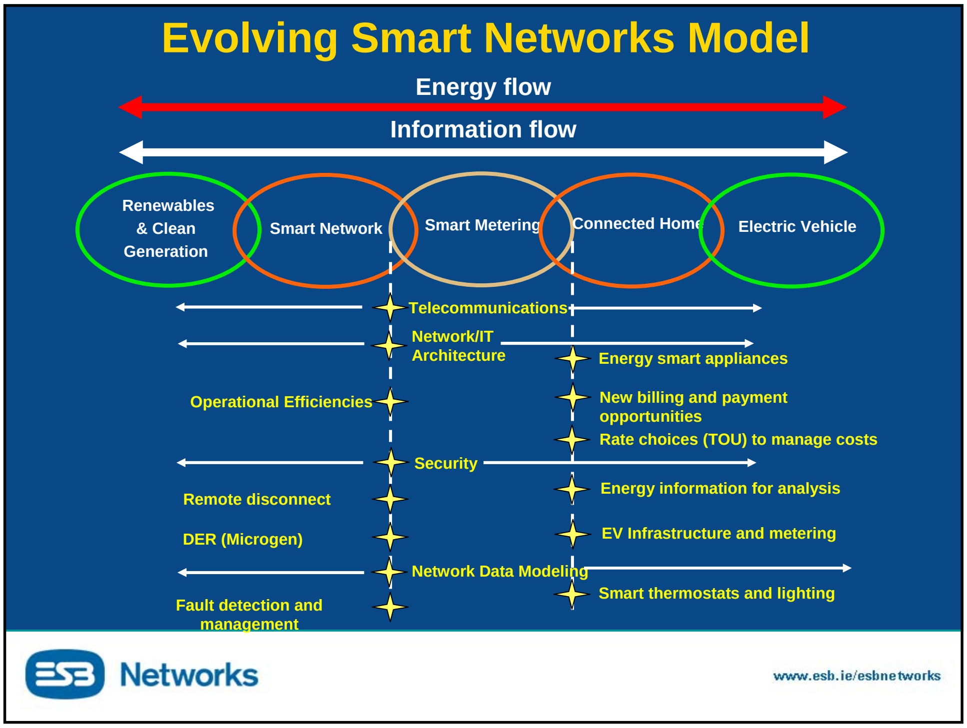
www.esb.ie/esbnetworks

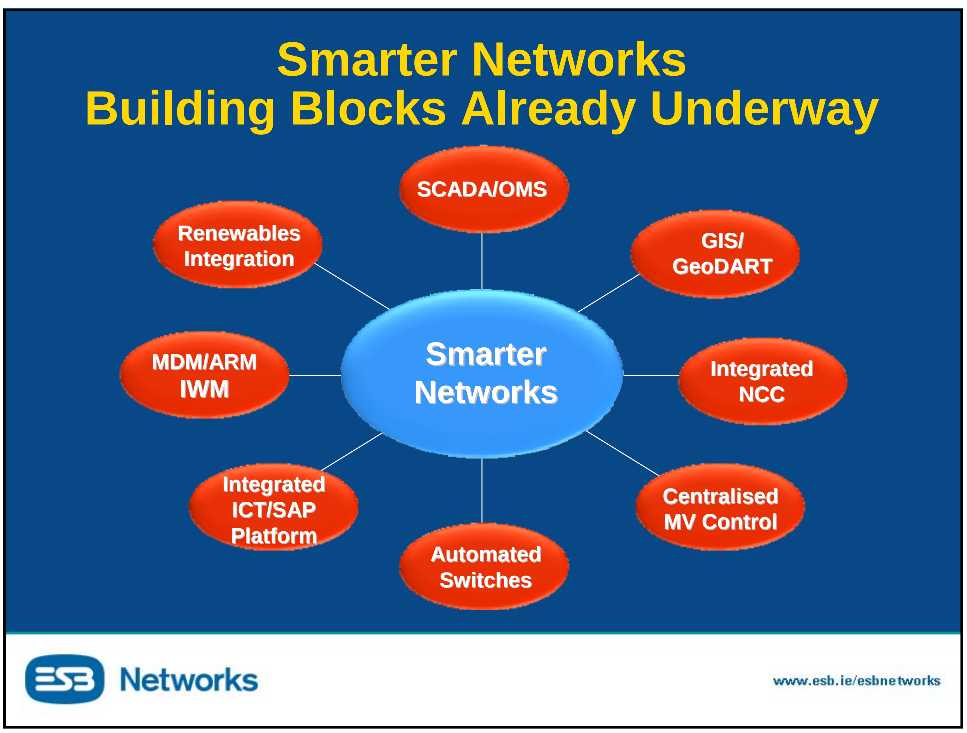
16,000km of NRP in 2005

Lower Achill to Los Angeles and back !

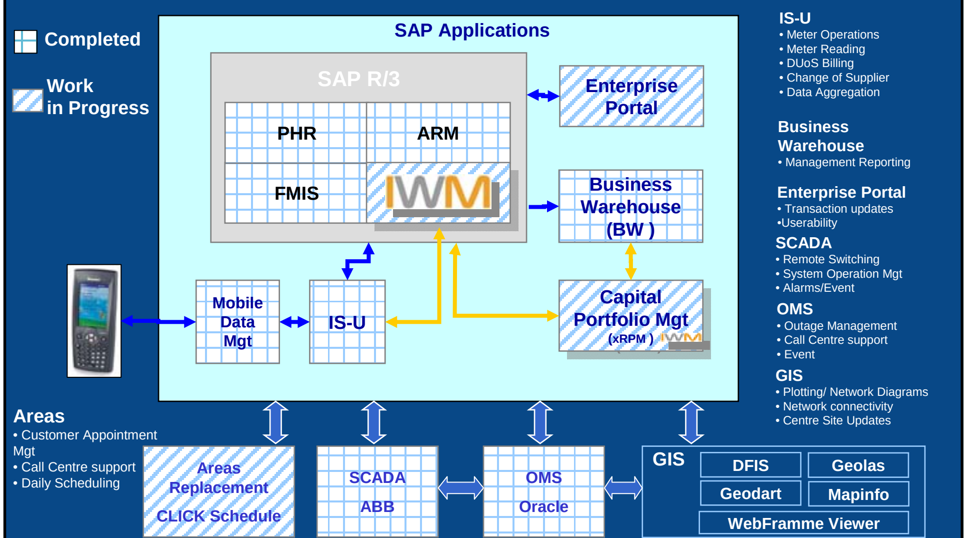

ESBN's Strategic Vision To 2020
World Class Sustainable Networks
Renewables at >40% connected
Electric Vehicles – 10% by 2020
Smart Grid – Smart Meter
Carbon Zero by 2035
And to be a Leader in Carbon Management and Energy Efficiency
Networks
www.esb.ie/esbnetworks


Sustainability Strategy
Renewables& Clean Generation
Smart Networks
Smart Metering
Connected Home
Distributed Energy Storage
(Plug-in Electrical Vehicles)
Internal Sustainability
A sustainable energy system connecting with energy aware interactive customers
Networks
www.esb.ie/esbnetworks


Evolving Smart Networks Model
Energy flow
Information flow
Renewables & Clean Generation
Smart Network
Smart Metering
Connected Home
Electric Vehicle
Telecommunications
Network/IT Architecture
Energy smart appliances
Operational Efficiencies
New billing and payment opportunities
Rate choices (TOU) to manage costs
Security
Remote disconnect
Energy information for analysis
DER (Microgen)
EV Infrastructure and metering
Network Data Modeling
Smart thermostats and lighting
Fault detection and management
Networks
www.esb.ie/esbnetworks

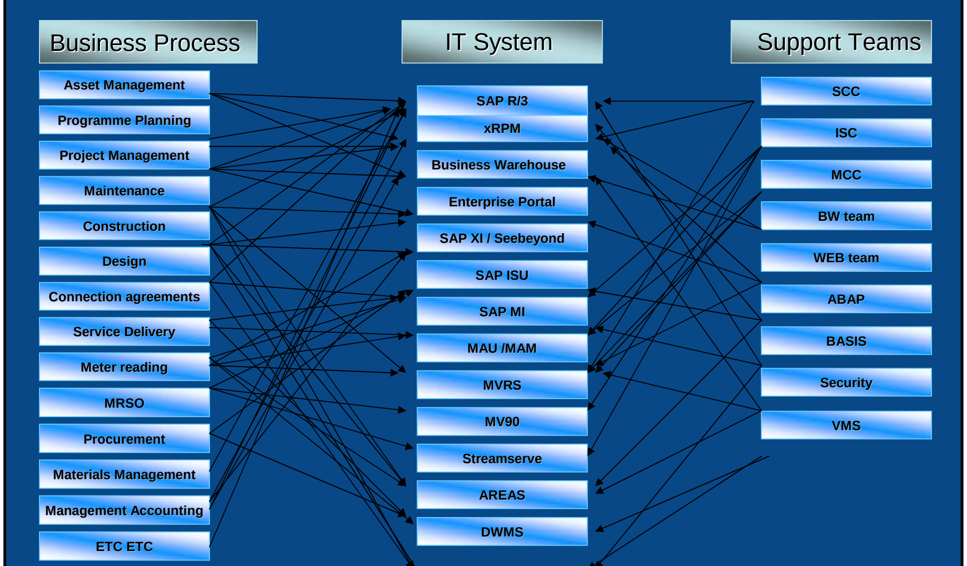

Smarter Networks
Building Blocks Already Underway
SCADA/OMS
Renewables Integration
GIS/ GeoDART
MDM/ARM IWM
Smarter Networks
Integrated NCC
Integrated ICT/SAP Platform
Centralised MV Control
Automated Switches
Networks
www.esb.ie/esbnetworks

ESB Networks IT Landscape 2009 (NITA - €100m)

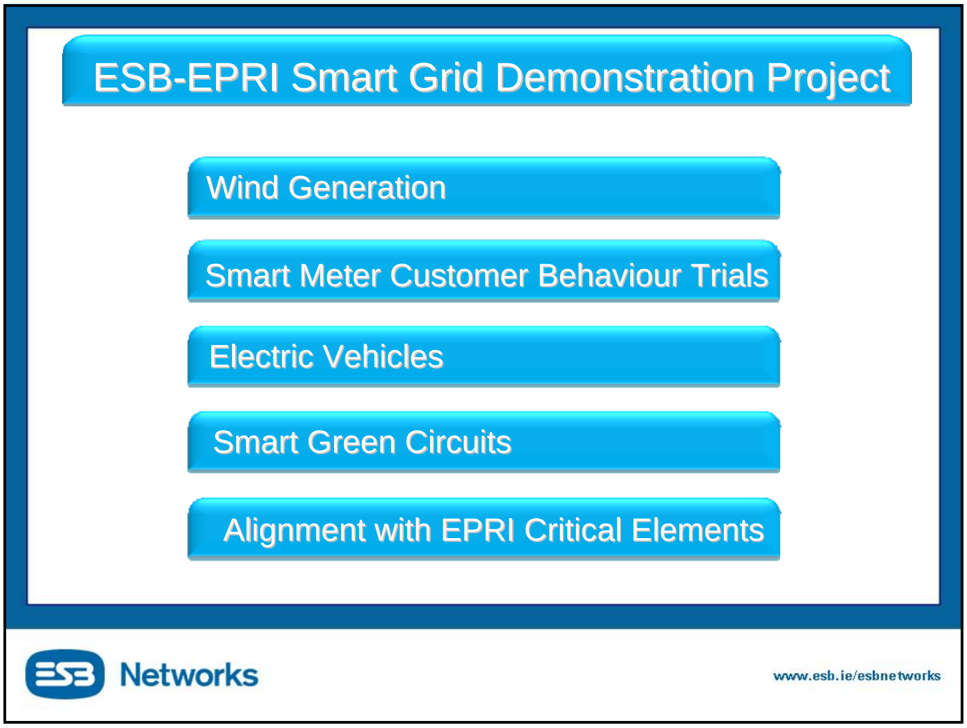


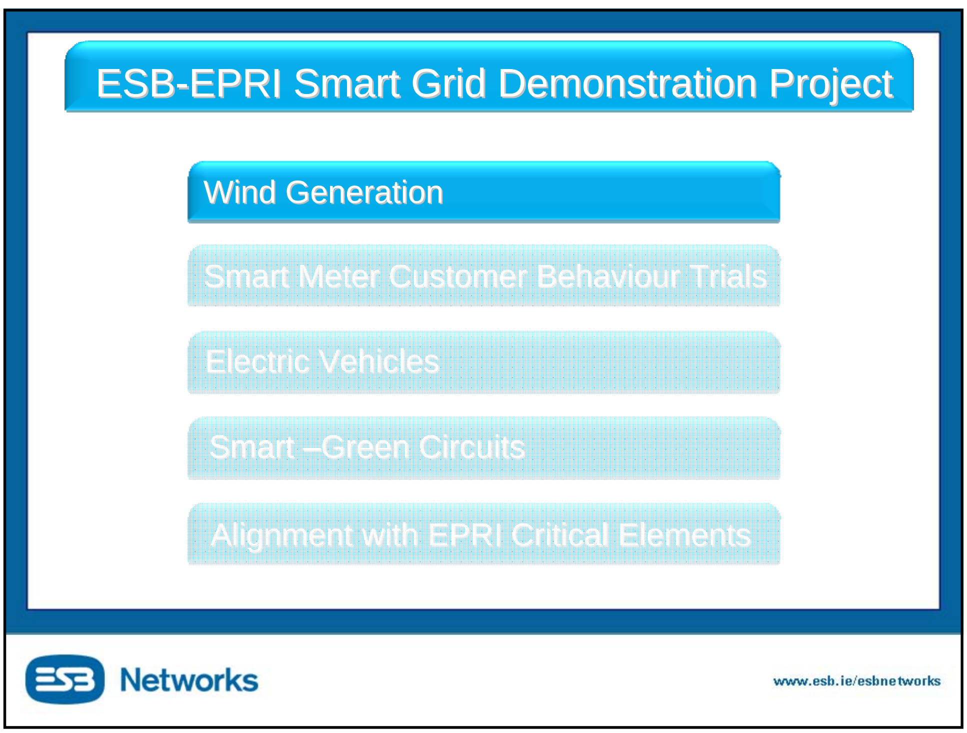
ESB Networks www.esb.ie/esbnetworks

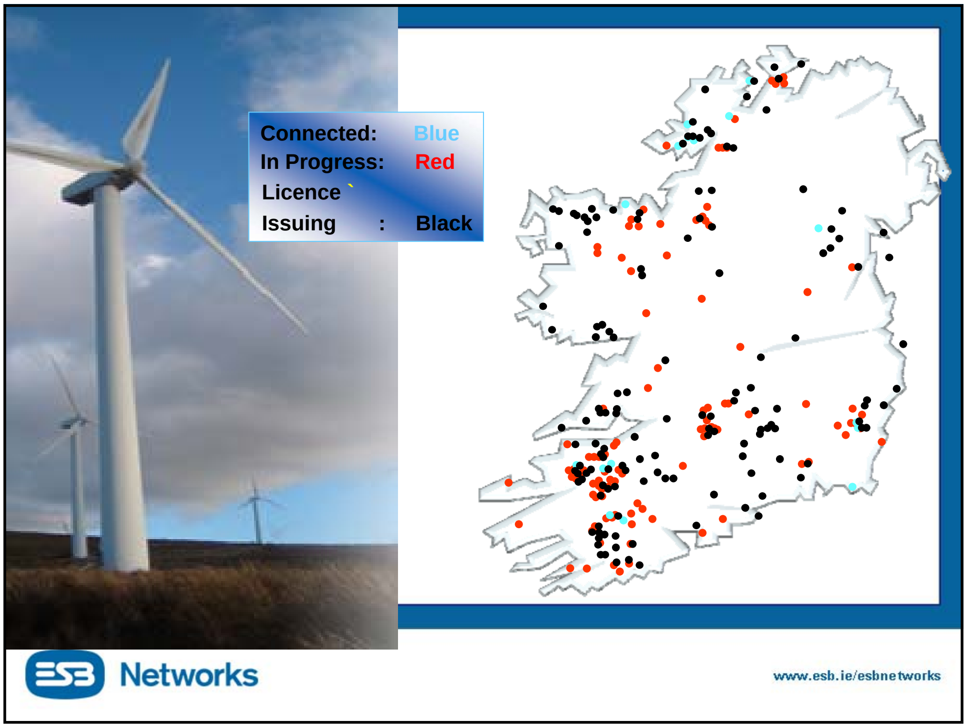
Business Process / IT System interdependence – Not joking!!

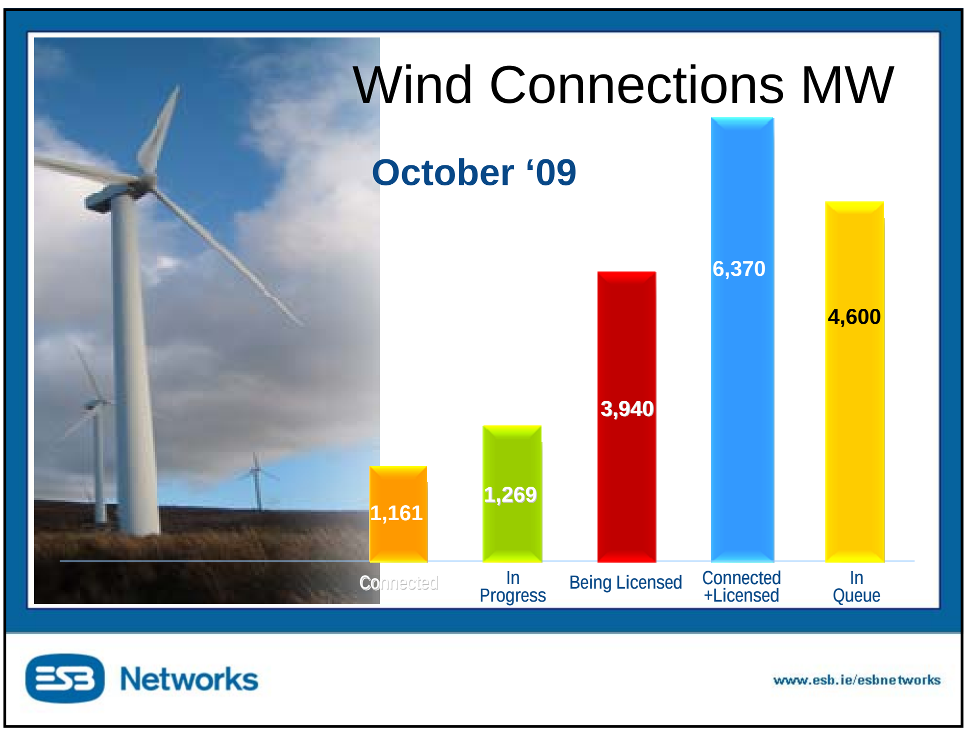


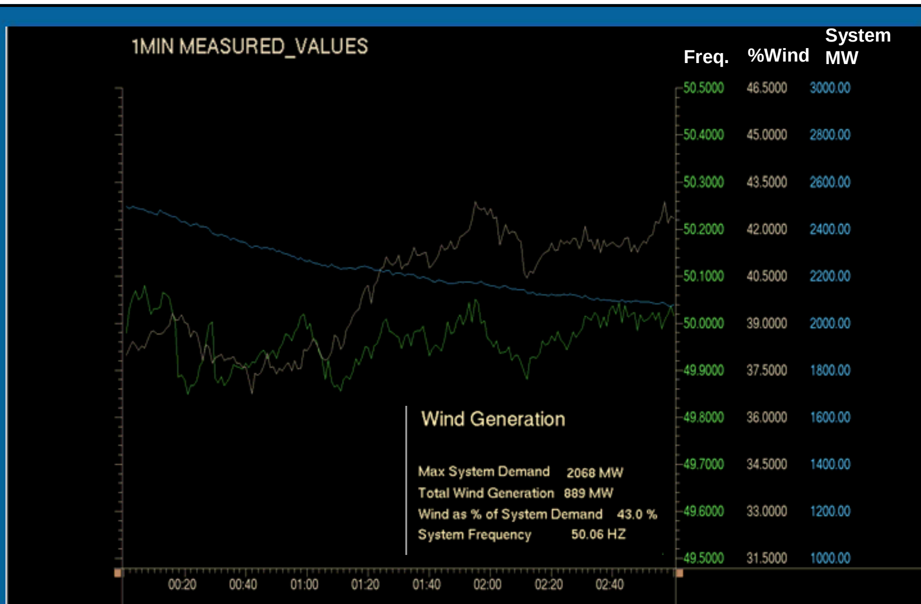
ESB Networks www.esb.ie/esbnetworks


ESB-EPRI Smart Grid Demonstration Project
Wind Generation
Smart Meter Customer Behaviour Trials
Electric Vehicles
Smart Green Circuits
Alignment with EPRI Critical Elements
Networks
www.esb.ie/esbnetworks

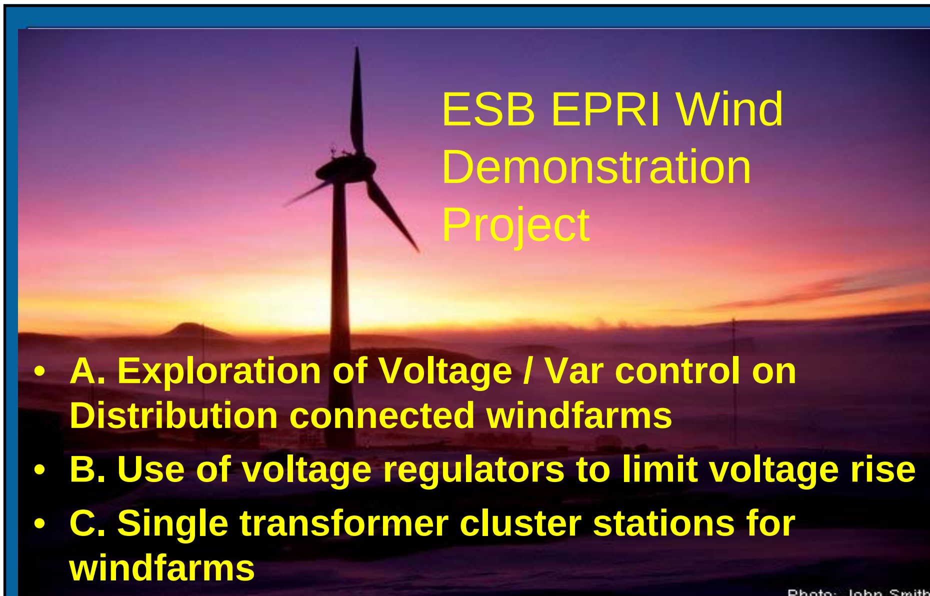

ESB-EPRI Smart Grid Demonstration Project
Wind Generation
Smart Meter Customer Behaviour Trials
Electric Vehicles
Smart –Green Circuits
Alignment with EPRI Critical Elements
Networks
www.esb.ie/esbnetworks


Connected: Blue
In Progress: Red
Licence Issuing : Black
Networks
www.esb.ie/esbnetworks


Wind Connections MW
October '09
1,161
1,269
3,940
6,370
4,600
Connected
In Progress
Being Licensed
Connected +Licensed
In Queue
Networks
www.esb.ie/esbnetworks



ESB Networks www.esb.ie/esbnetworks



ESB EPRI Wind Demonstration Project

- **A. Exploration of Voltage / Var control on Distribution connected windfarms**
- **B. Use of voltage regulators to limit voltage rise**
- **C. Single transformer cluster stations for windfarms**

Photo: John Smith

ESB Networks www.esb.ie/esbnetworks

Project A - Exploration of Voltage/Var control - Drivers

- Modern wind turbines have to varying degrees, the ability to operate in various modes and at a range of Power Factors
- Distribution/Grid Codes now require this capability
- Eirgrid want to see DSO take a more active part in VAR control
- Distribution connected Wind farms may wish to avail of ancillary service contracts

ESB Networks www.esb.ie/esbnetworks

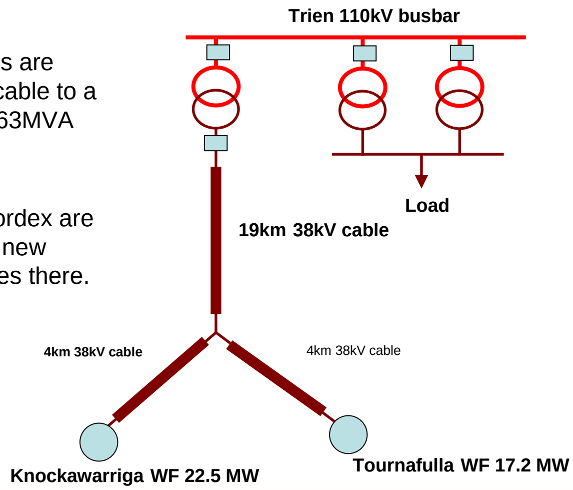
Project A Objectives

- To prove the viability of distribution connected windfarms operating in constant voltage mode
- To assess impact on DSO busbar voltage
- To assess potential for hunting between controllers
- To verify software modelling so that it can be used in future installations
- To inform second stage where load customers are directly affected

ESB Networks www.esb.ie/esbnetworks

Proposed stage 1 sites

- Knockawarriga and Tournafulla windfarms are connected via 38kV cable to a dedicated 110/38kV 63MVA transformer
- In Knockawarriga, Nordex are keen to demonstrate new features of the turbines there.



Networks www.esb.ie/esbnetworks

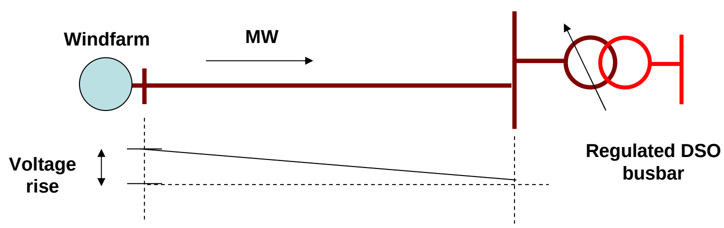
Implementation steps – Stage 1

1. Secure agreement in principle with owners – Done
2. Meet owners to agree details and agree risk cover/spread
3. Ensure that pre-trial data is logged from on-site PQ meters
4. Determine an appropriate voltage setpoint for Knockawarriga and model behaviour
5. Set Knockawarriga to constant voltage operation
6. Monitor for x months – compare with predicted behaviour
7. Determine an appropriate voltage setpoint for Tournafulla and model behaviour
8. Set Knockawarriga to constant voltage operation
9. Monitor for x months – compare with predicted behaviour
   Evaluate overall results – particularly impact on 38kV voltage at Trien

Networks www.esb.ie/esbnetworks

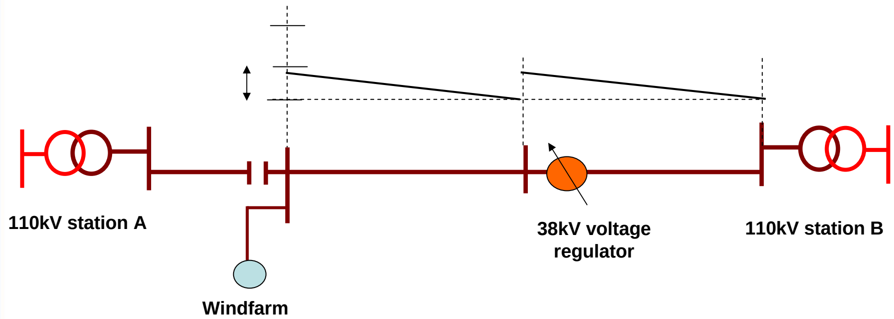
Project B - Use of voltage regulators to limit voltage rise - Background

- Voltage rise on Distribution networks due generation is a well known phenomenon
- For the situation as shown below, the voltage at the windfarm site will be higher than that at the regulated DSO busbar
- The voltage at the WF site cannot be allowed to exceed certain limits



Use of voltage regulators to limit voltage rise - Situation

- **Innovation: Use 38kV voltage regulator on backfeed**



Project B Objectives

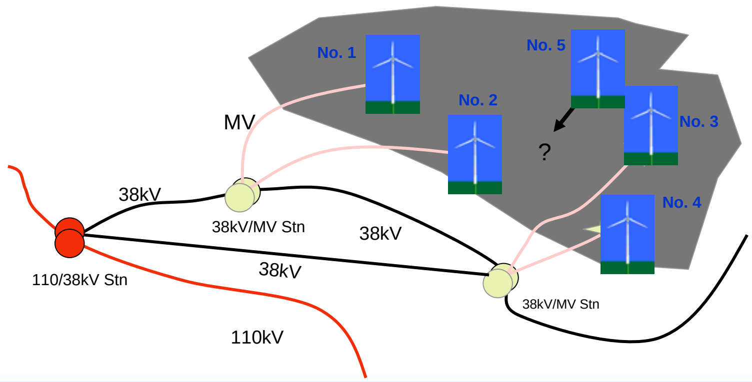
- To select a site for implementation [Done]
- Monitor voltage at relevant nodes post installation
- Verify loadflow modelling

Project C - Single Trafo Cluster Station

- Develop economic design of HV/MV substation which can facilitate connection of large amounts of radially fed windfarms using single trafo station design
- Reliability less than for conventional station but costs are substantially reduced
- Windfarms do not require high reliability connections.

Example of Sequential Approach

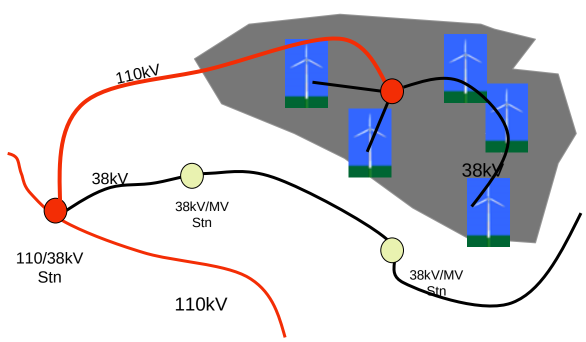
- Windfarms connected in sequence shown
- 38kV re-enforcements are driven until windfarm 4 uses all available capacity
- When windfarm 5 is processed, there is no more local capacity left



ESB Networks www.esb.ie/esbnetworks

Example of Gate Processing

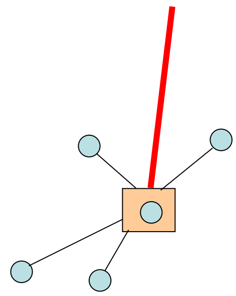
- When all five are considered together, it becomes clear that the most efficient connection method is a new 110kV “cluster “station



ESB Networks www.esb.ie/esbnetworks

Single transformer cluster stations for windfarms - Background

- Gate System drives the need for new build cluster stations
- In the determination of the least cost method of connection for the group, DSO constrained to use combinations of standard size transformers available
- Standard sizes evolved from load planning philosophy



Project Objectives

- Seek input from wind industry on possible transformer sizes [Done]
- Engage ESBI to study and report on such aspects as:
  - Short level implications
  - Percentage impedance
  - Voltage Rise
  - Switchgear implications SC and TRV
  - Spares
- Discuss outcome internally
- If positive, go to enquiry for additional transformer sizes

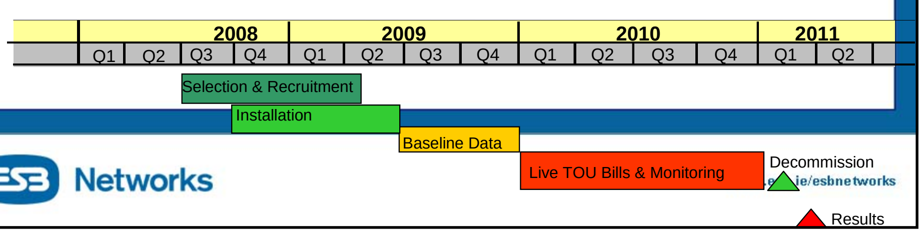
ESB-EPRI Smart Grid Demonstration Project

- Wind Generation
- **Smart Meter Customer Behaviour Trials**
- Electric Vehicles
- Smart-Green Circuits
- Alignment with EPRI Critical Elements

Networks www.esb.ie/esbnetworks

Objectives of Customer Behaviour Trial

- Objective is 'to ascertain the potential for smart meter technology to effect measurable change in consumer behaviour, which will result in the reduction of peak demand and overall energy use, when operated with appropriate DSM initiatives'
  - **6,400 customers**
  - **One year profile data per customer (at least 6 actual months) for benchmark period**
  - **One year of stimuli**
  - **Real Tariffs applied to Real customers**
  - **Suppliers to be given daily validated half hourly data each day**
  - **Final conclusions by CER based on ESRI National Business Case Study Q1 2011**



Networks www.esb.ie/esbnetworks

Managing Demand & Consumption

- Energy Awareness


- Tariff Incentives/penalties

- Prepayment Options

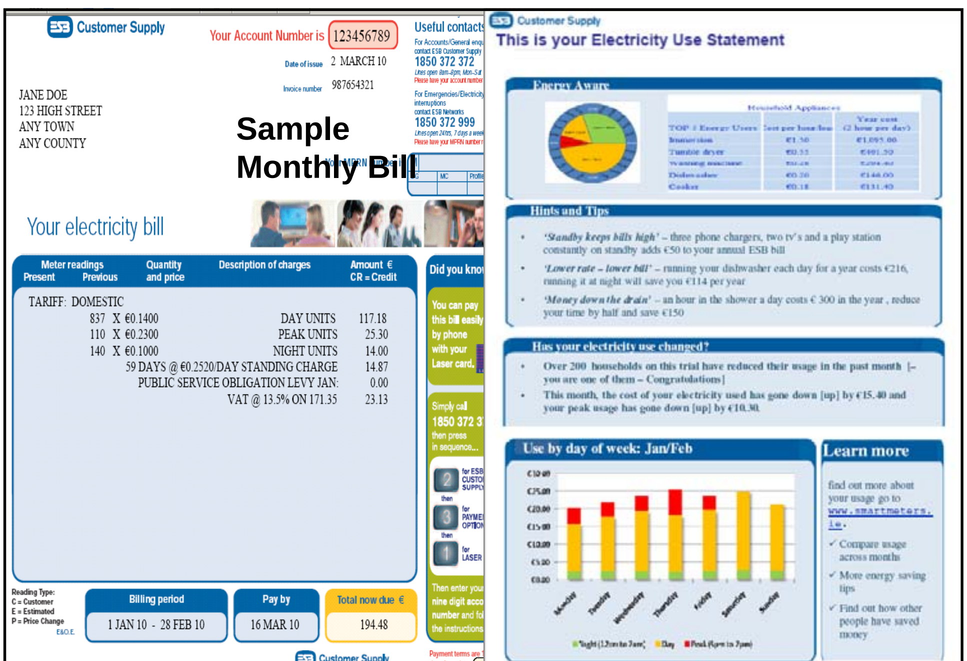
- Control Opportunities

- Electricity Import / Export



Networks

www.esb.ie/esbnetworks

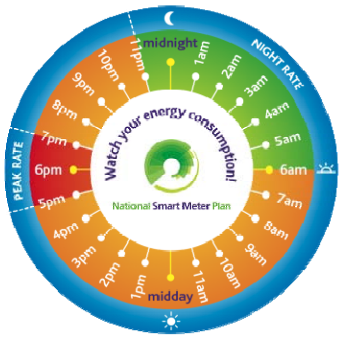


Sample Monthly Bill

Networks

www.esb.ie/esbnetworks

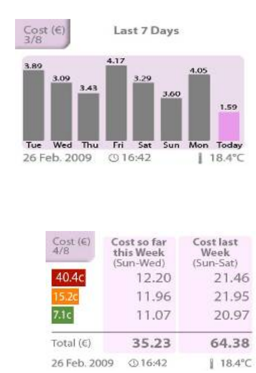
ToU Tariffs for Pilot



- Jan 09 on
- 'make whole concept'
- Multi TOU Trial tariffs based on baseline tariff
- Control Group
- CER final decision

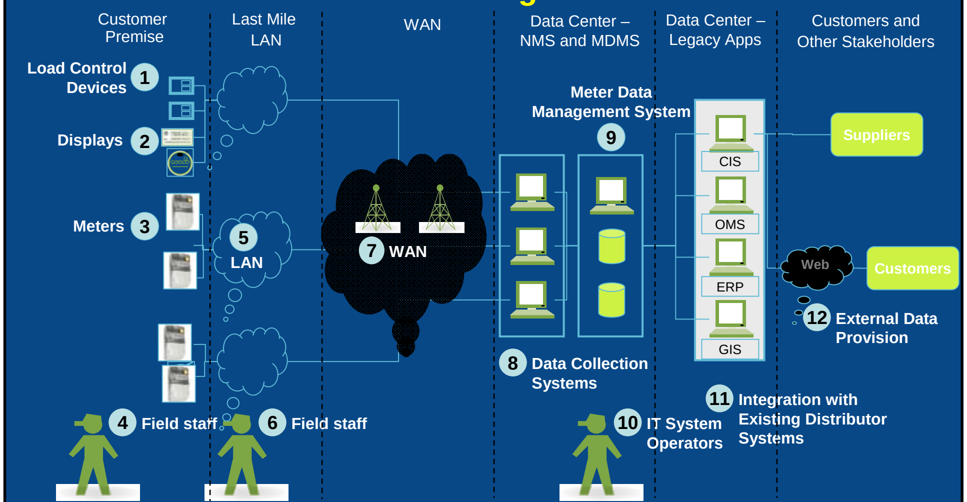
ESB Networks www.esb.ie/esbnetworks

In Home Display Developed for Pilot – by Customers

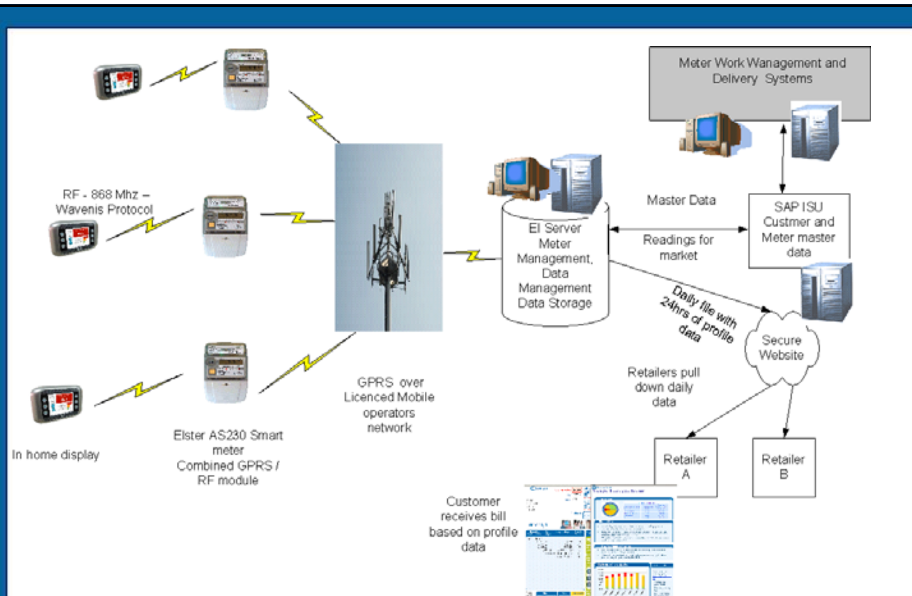


ESB Networks www.esb.ie/esbnetworks

AMI is more than just meters – it's a complex integration of sensors, devices, communications, and software technologies



Networks www.esb.ie/esbnetworks



Networks www.esb.ie/esbnetworks

Project Objectives

- Target is how smart meters to enable demand and consumption in countries with a winter peak - Largest trial of its kind in Europe
- independently verified statistical experiment
- Findings on %reduction accurate to within 1%.
- Its success is key to the roll out of smart metering in Ireland.
- Puts the customer requirements at the centre of smart metering system design
- ESBN would be pleased to share our learnings with EPRI.

ESB-EPRI Smart Grid Demonstration Project

- Wind Generation
- Smart Meter Customer Behaviour Trials
- Electric Vehicles
- Smart-Green Circuits
- Alignment with EPRI Critical Elements

Objectives

- To assess the network impact of electric vehicles, with an emphasis on field trials, customer participation and charging strategies.
  - Assessment on amount of EV/Charging allowable on existing network
  - Identification of low cost investments required to increase Network EV Capacity
  - Assessment of impact on Power Quality of EV and how this can be kept within standard without unduly limiting use of EV
  - Assess scope for use of EV in DSM
  - Assess scope for future use of Electric Vehicle to Grid.

Networks

www.esb.ie/esbnetworks

Electric Vehicles Are Back!

Networks

www.esb.ie/esbnetworks

Informal EV Standardisation Group

Electric Utilities

ALPIQ, EDF, Vattenfall, ESB, RWE (The energy to lead), Endesa, EnBW, Iberdrola, edp (feel our energy), e·on, essent, Enel (L'energia che ti ascolta)

Automotive Manufacturers

Nissan, Renault, Mercedes-Benz, PSA Peugeot Citroën, DaimlerChrysler, Ford, Porsche, Fiat Group, Toyota, Audi, Mitsubishi Motors, Opel, Volkswagen, Volvo

ESB Networks www.esb.ie/esbnetworks

ESBN research

Standard Charging

elektromotive

Coulomb Technologies — Fueling the Electric Transportation Industry

Fast Charging Pilot

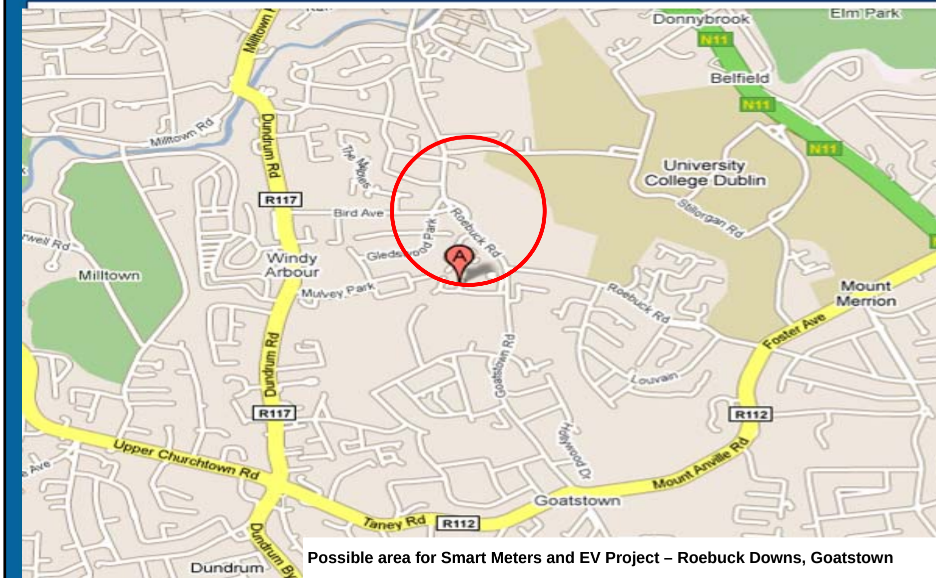
AV, Micro-Vett, edp, EPYON

ecOtality

ESB Networks www.esb.ie/esbnetworks


Project Scope
Electric Vehicle
www.esb.ie
– Suburban with mix of OH/UG Networks e.g. Goatstown in Dublin
– Rural – 15kVA Transformer feeding EV e.g. Ennis
Model Network
– Measure load characteristics of typical EV's
– Populate model with varying penetrations of EV's
– Assess impact on Voltage, Capacity and PQ of EV's
Equip up to 20 houses with EV Charging points beside outside Meter Box & SmartMeter
– Assess Charging Point arrangement
– Trial EV Charging by loaning EV to selected residents.
– Compare Measured results with model

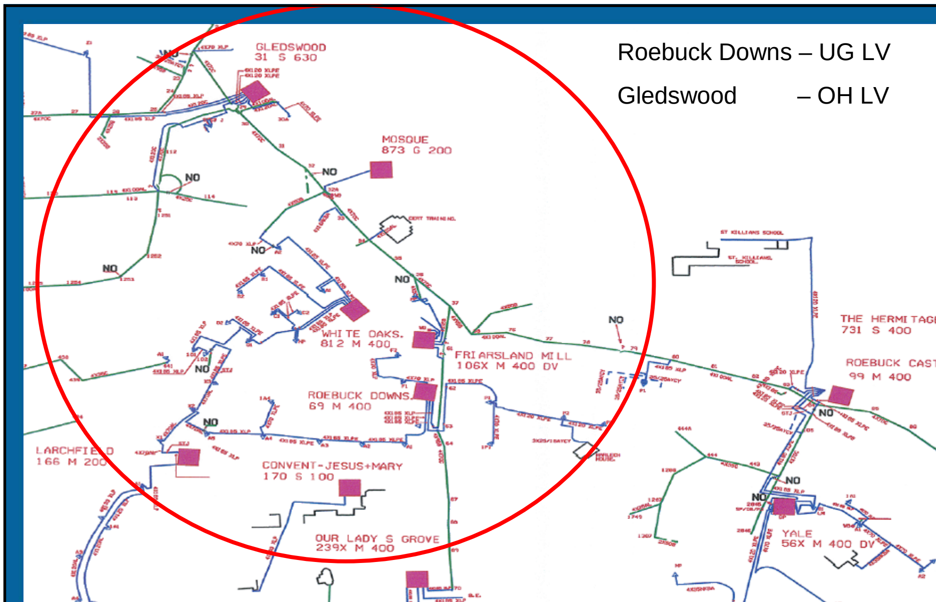

Project Scope
Electric Vehicle
www.esb.ie
• Assess feasibility of faster charging on LV network by using SmartMeter to share charging capacity
• Assess capacity of LV Network for EV, based on likely statistical household load patterns, influenced by Tariffs (e.g. inference from Night Tariff impact on use of Day load)
• Assess potential barriers to future Vehicle to Grid
• Assess possibility of using EV as ballast load for WIND, using HAN to control in response to Wind level on system
• Establish upstream impact of high EV Penetration rates (MV, 38kV and 110kV)



Possible area for Smart Meters and EV Project – Roebuck Downs, Goatstown

- *In Dun Laoghaire/Rathdown and about a mile beyond Dublin Corporation*
- *Mixture of new UG Network, Older OH Network in Semi-Detached estates*
- *Mixture of Infill Apartment blocks with large School and Mosque*
- *Close to UCD*

ESB Networks

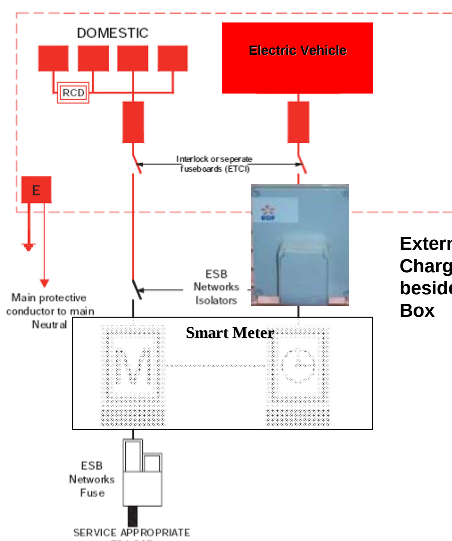


Roebuck Downs – UG LV

Gledswood – OH LV

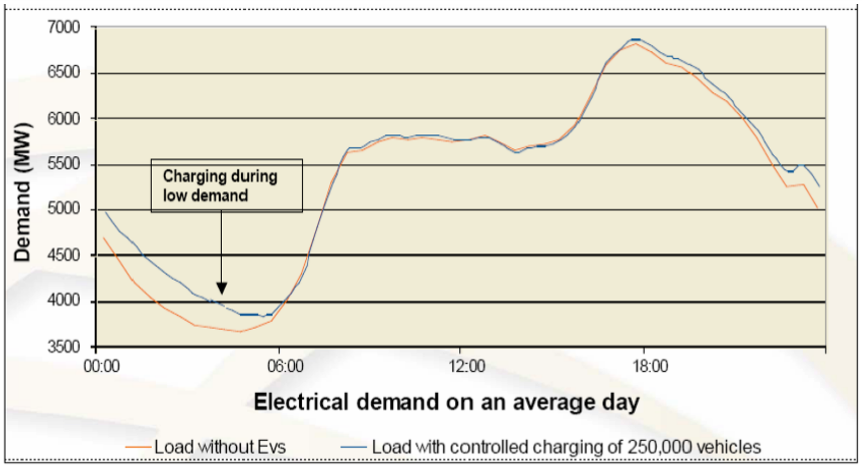
ESB Networks

www.esb.ie/esbnetworks



External Charge Unit beside Meter Box

Type	Electrical	Resulting Charge	Power
Standard	230V 16A 1 or 3 phase	100% 6 – 8 h	3kW 10KW
Opportunity	400V 32A	50% in 30 mins	22kW
Emergency		20km in 10 mins	
Range Extension	400 v 63A	80% in 30 mins	44kW



Source: Eirarid

Impact of 10% Passenger Vehicles on Demand Profile in 2020

Potential Benefits to ESB

- In Depth assessment of impact of EV on Urban and Rural networks
- Testing EV Charging in Domestic Premises
- Evaluation of potential to increase charging rates or expand charging times without incurring extra costs for network Infrastructure

ESB-EPRI Smart Grid Demonstration Project

- Wind Generation
- Smart Meter Customer Behaviour Trials
- Electric Vehicles
- **Smart-Green Circuits**
- Alignment with EPRI Critical Elements

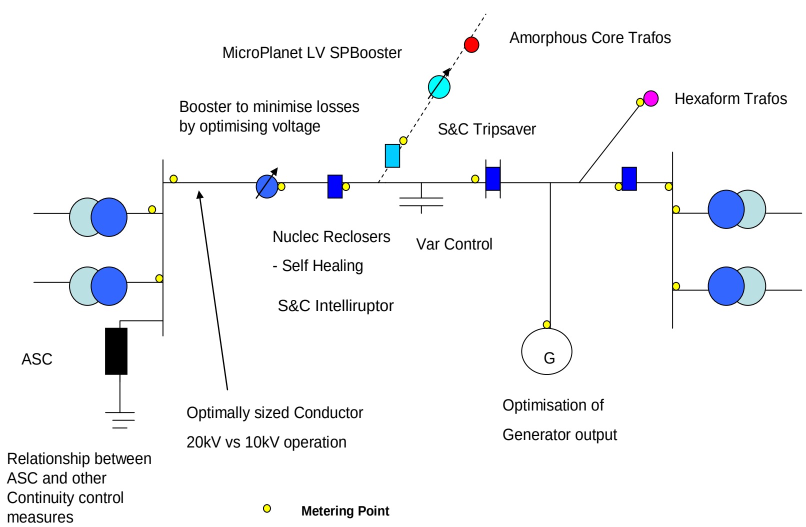
Objectives

- To **develop and test** improved methods for estimating losses on rural feeders
- To assess and demonstrate methods of **reducing losses**.
  - Voltage Upgrading i.e. 20kV Conversion
  - Dynamic re-configuration of networks to minimise losses
  - Re-conductoring
  - Amorphous core transformers
  - Installation of Capacitor banks
  - Lower average supply voltage using line drop compensation

Efficient Networks

Networks Loss Reduction Plan

- 20kV Conversion (48,000 km by 2012)
- 38kV line rebuild (300km)



Green Circuits Proposed

- 4 MV circuits proposed
  - 10kV Circuit with 660kW Windfarm
  - 20kV Circuit with High Losses where Landfill Gas DG to be connected
  - 2 x 10kV Circuits where analysis shows 20kV Conversion apposite
- MV Circuit Typical Features :
  - Circuit contains two interconnected feeders between two 38/MVsubstations
  - 25 – 40 km Route length between 38kV stations
  - Serves 800 – 1,200 customers
  - 250 - 400 single phase transformers + some three phase transformers
  - Existing losses believed to be significant.
  - Some small scale dispersed wind generation

ESB Networks www.esb.ie/esbnetworks

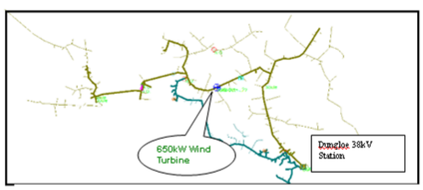


Figure 5-4: Circuit 2 Example

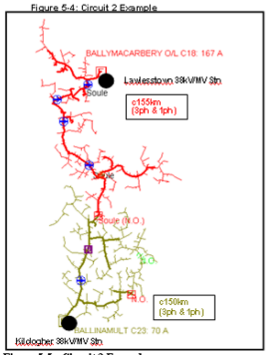


Figure 5-5 : Circuit 3 Example

ESB Networks www.esb.ie/esbnetworks

Analysis

- Phase 1 : Use ½ Hour load flows and DSS to estimate losses impact of:
  - 20kV conversion
  - Dynamic sectionalising
  - Capacitor banks
  - Losses impact of better phase balancing
  - Voltage Reduction at MV using Regulator, at LV using Microplanet
  - Economics of amorphous core transformers
- Phase 2 : Test out /demonstrate solutions that indicate positive Cost Benefit

ESB Networks www.esb.ie/esbnetworks

Expected Benefits to ESB

- More effective planning of rural networks
  - Better method for estimating load, voltage and losses
- New techniques to minimise losses may be established
  - Re-balancing of the network
  - Dynamic re-configuration
  - Capacitor banks (not currently deployed by ESB)
  - Voltage reduction

ESB Networks www.esb.ie/esbnetworks

Summary

- ESB looking forward to working with EPRI on Smart-Networks Initiative
- ESB welcomes comments and suggestions from all other utility participants
- ESB network happy to share any points of learning with utilities here today

ESB-EPRI Smart Grid Demonstration Project

- Wind Generation
- Smart Meter Customer Behaviour Trials
- Electric Vehicles
- Smart-Green Circuits
- Alignment with EPRI Critical Elements

EPRI 6 Critical Elements/Criteria

1. Integration of Multiple types of Distributed Energy Resources
   - DG connected Windfarms providing Reactive Power
   - Customer Behaviour Trials and Demand Response
   - Electric Vehicles – DSM ballast for Wind and V2G
   - SmartGreen Circuits – Landfill gas and Wind

2. Critical Integration Technologies & Standards
   - Common Information Model (CIM) for TSO/DSO Comms
   - IEC 60870, IEC 101, ICCP
   - Customer Behaviour Trials (AMI, IHD, Wavenis Protocol, 868MHz, GPRS)
   - Electric Vehicles, GPRS Charging Posts, Charging Signature Provision
   - SmartGreen Circuits, Smart Metering, OpenDSS

EPRI 6 Critical Elements/Criteria (cont'd)

3. Dynamic Rates of other Approaches connecting Retail customers to Wholesale Conditions
   - CBT: Combination of TOU, Stimuli & Control
   - EV: Rates to encourage charging in non-peak periods
   - Smart Meter Trials feed into Green Circuits Analysis

4. Integration w/System Operations & Planning
   - Wind: Setpoint for VAR issued by TSO to DSO - Cluster operates as unit to reach and maintain setpoint (SCADA)
   - Customer Behavior Trials & EVs: Data integrated into system planning. Evaluated to compensate for intermittent wind
   - SmartGreen Circuits: Costs/Benefit Analysis of wind on losses & improved voltage regulation (System Impact Studies)

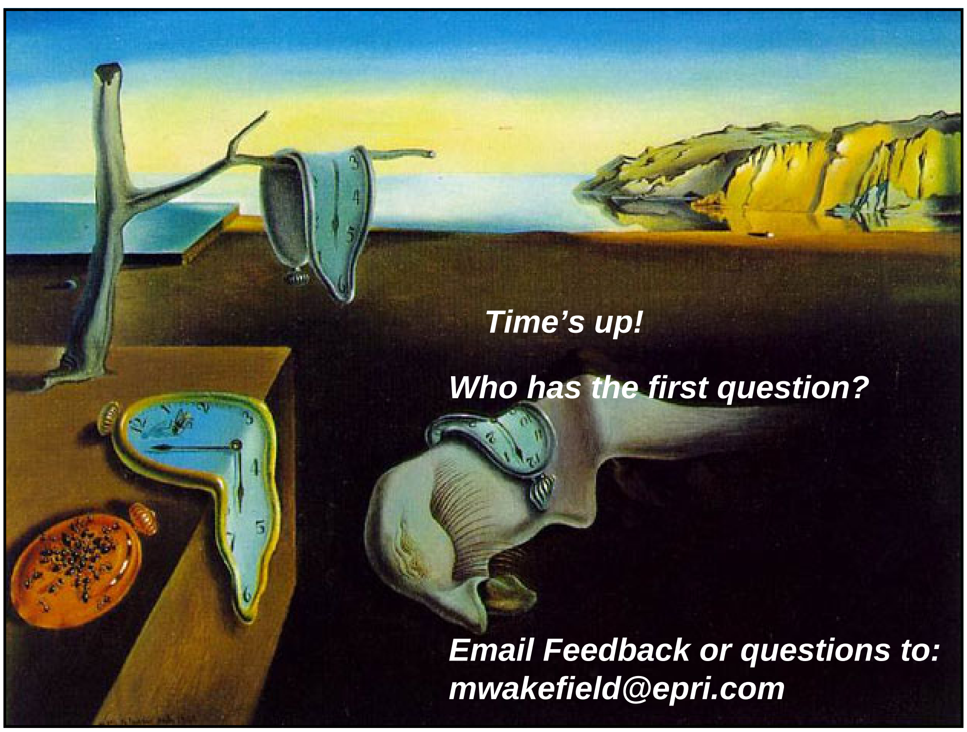
ESB Networks www.esb.ie/esbnetworks

EPRI 6 Critical Elements/Criteria (cont'd)

5. Compatibility with EPRI's Initiative & Approach
   - Leverage IntelliGrid Methodology: Use Case Development
   - Cost Benefit Analysis
   - Project will support integrating varying types of DER at multiple levels of ESB's system

6. Leverage Additional Funding Sources
   - Project Funded By ESBN
   - Inkind support from turbine manufacturer & Vendors
   - Support from Irish Electricity Regulator (CBT)
   - ESBN/Government Partnership on EV's
   - University Analysis supported by Science Foundation of Ireland

ESB Networks www.esb.ie/esbnetworks



Support Slides

ESB Networks

www.esb.ie/esbnetworks