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Pre-saturated Core Fault Current Limiter (PCFCL) Project

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WHAT IS A FAULT CURRENT?

WHY DOES IT MATTER?

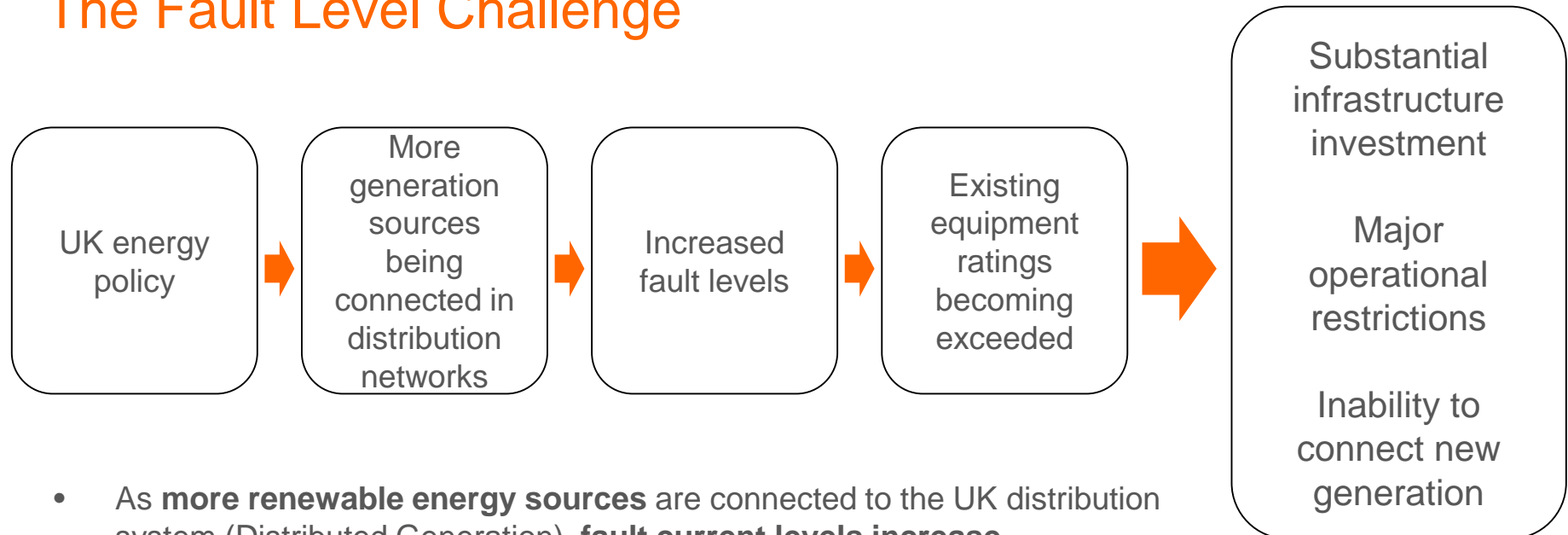


Network Faults

- Faults within electrical power systems are inevitable
 - equipment failures (cables, transformers, switchgear, etc), often due to old age
 - external factors such as lightning strikes, overloading, digging through cables, etc
- Consequences of faults
 - cause very high electrical currents
 - lead to high electrical, thermal and mechanical stresses on distribution system equipment
 - closing a CB onto a fault risks exceeding mechanical stress limit
 - opening a CB during a fault risks exceeding switchgear opening limit
 - personnel safety risks if switchgear fails, particularly during switching



The Fault Level Challenge



- As **more renewable energy sources** are connected to the UK distribution system (Distributed Generation), **fault current levels increase**
 - CHP systems typically have fault contribution of 5-8 x rating
 - PV typically 1-1.2 x rating
 - Wind depends on system design
- Networks are reaching fault current rating limits
 - e.g. 20% of UKPN's London network has high fault levels (>95% of rating)



Consequences

- Conventional (passive) techniques to manage these fault currents introduce **additional cost and negative impact** on operational complexity, power quality, power system stability, reliability and security of supply
- A significant number of new DG projects do not proceed as a consequence, and fault current levels are becoming a **major barrier** to the widespread deployment of low-carbon distributed **generation**
- Also a major barrier to **smart distribution networks** with increased operational efficiency, flexibility, reliability and resilience
- Active Fault Current Limiters (FCLs) will provide a credible, commercially acceptable means of overcoming these barriers

Conventional (Passive) Fault Current Management Techniques	
Switchgear reinforcement	Standard approach requiring high investment in most cases; also assumes switchgear exists at required ratings
Network splitting & reconfiguration	Low cost but leads to operational restrictions, and often lower power quality
Passive current limiting reactors & high impedance transformers	Comparatively low cost but introduces voltage drops and much increased steady-state losses
Sequential switching	Higher operational complexity, not fail-safe so a higher risk solution
Connecting DG at higher voltages	Increased connection infrastructure investment



GridON's FCL Technology

GridON

- Removes fault level constraints without costly network upgrades
 - Enables more distributed generation, with shorter connection times and reduced costs
 - Enables smart networks with increased efficiency, flexibility, reliability and resilience
- Faster implementation than switchgear replacement
- Fully scalable for use at all distribution and transmission voltages
- Provides:
 - Instantaneous, self-triggering response to network faults (without reliance on sensors or other components)
 - Immediate recovery following clearance of a fault without network interruption, and suppression of multiple consecutive faults (allowing use in 'incomer' applications)
 - Enhanced fault limiting capability relative to other pre-saturated core fault current limiters
- Breakthroughs in design remove the need for superconducting components and associated cryogenic systems
- Inherent cost-effectiveness, ease of installation, reliability and minimal maintenance requirements
- GridON's is the first such fully tested, commercially viable, non-superconducting pre-saturated core fault current limiter
- GridON partnered with Australian-based Wilson Transformer Company for detailed design, manufacture and test





PROJECT OVERVIEW



Project Aims

- Having selected a potentially world-leading second-generation FCL technology (GridON's PCFCL), develop this FCL to the point at which it meets the genuine needs of distribution network operators (which no product has to date achieved)
- Assess and demonstrate performance in service for two years
- Define the Commercialisation Pathway, incorporating all aspects of further technical developments, supply chain planning, unit price development, etc to achieve a fully commercialised product
- Thereby, accelerate the commercialisation and deployment of FCLs in significant numbers on UK distribution networks

Impact

- By removing constraints on the network operation, this will **enable smart distribution networks** with **improved operation, flexibility and efficiency**, and will **remove key technical and commercial barriers** to the installation of large quantities of low-carbon distributed generation and energy storage – all of which are essential if the Government's 2050 targets are to be met



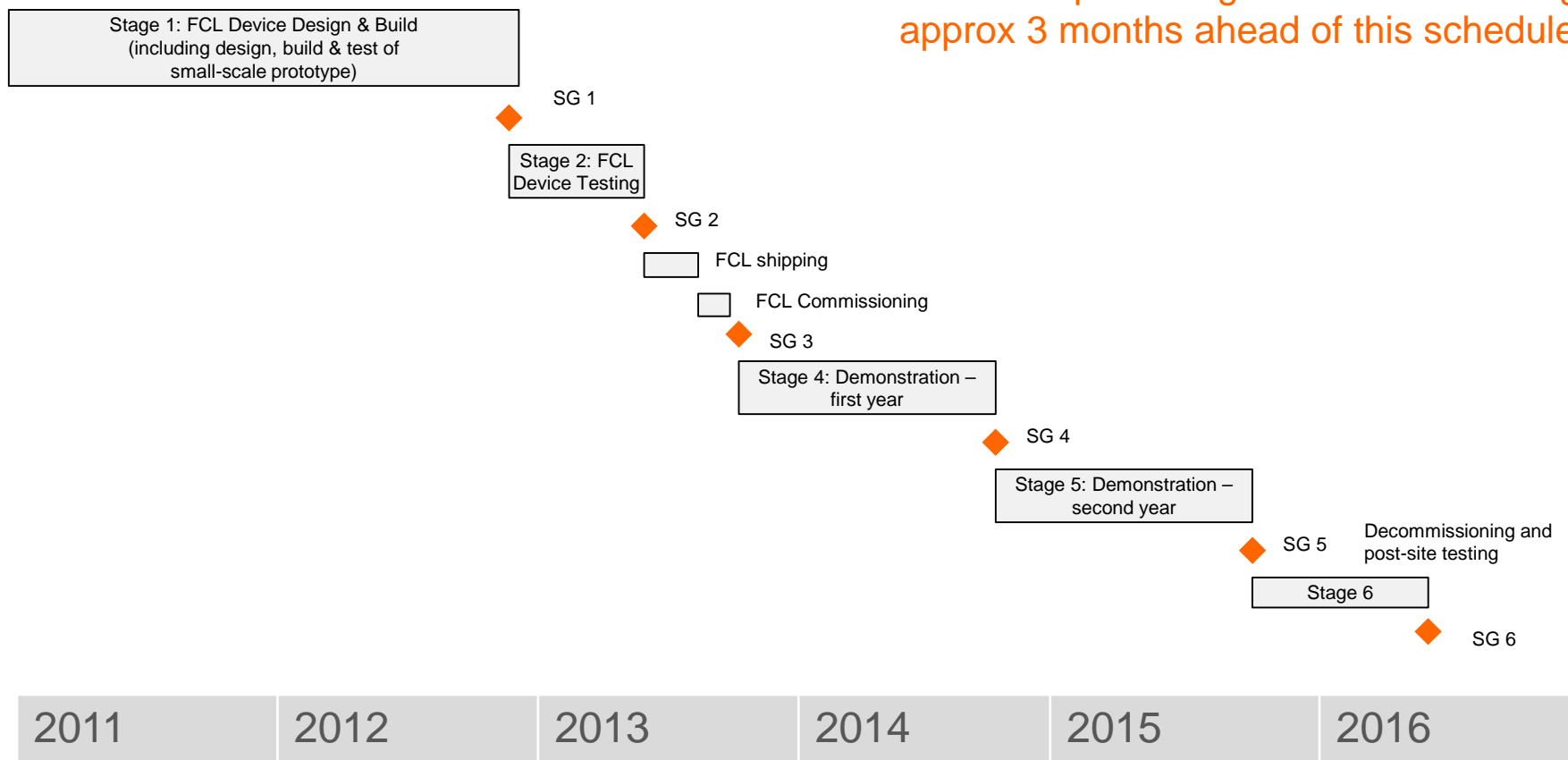
Consortium Members & Key Subcontractors





Plan Overview

FCL commissioning actually achieved,
and subsequent stages therefore running,
approx 3 months ahead of this schedule.





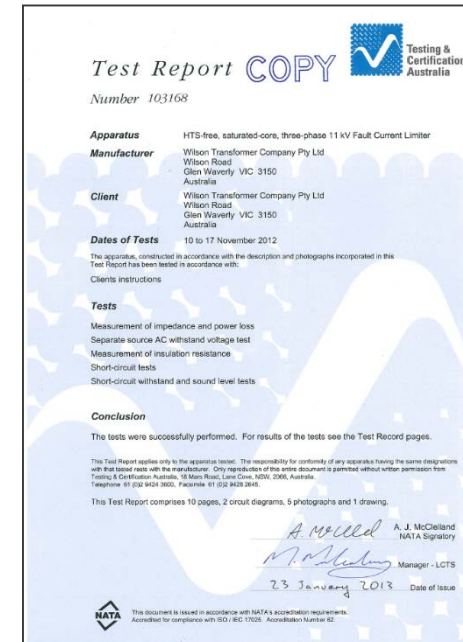
1MVA Prototype Development

- Prior to project, technology initially developed and tested only at bench-top scale
- First stage of project included development of 1MVA Prototype (i.e. 1/10th power rating)
- Fully designed, built and tested



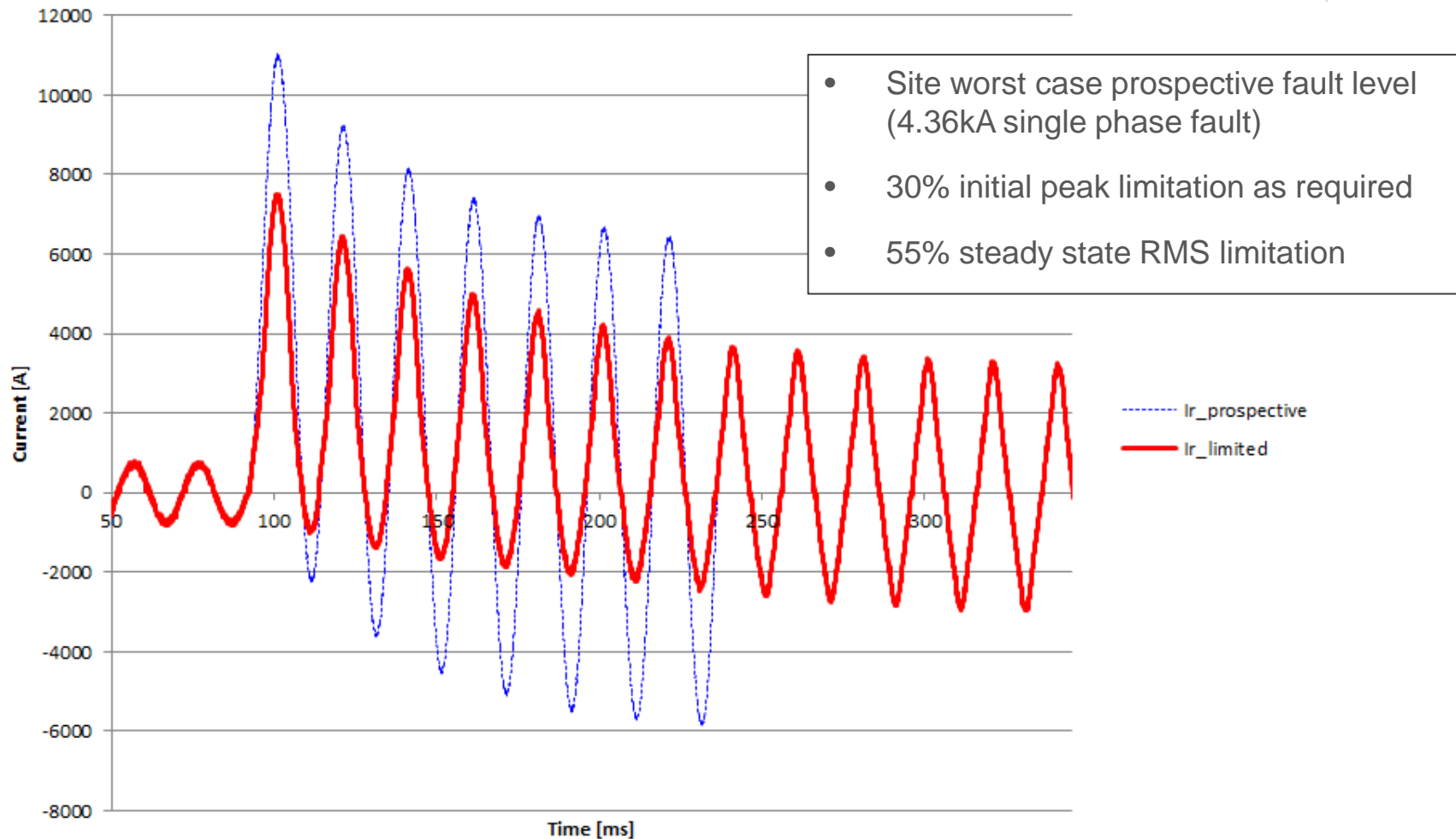
Main 10MVA FCL Device

- Learning from 1MVA prototype incorporated into development of 10MVA FCL Device
- Thoroughly tested in WTC's factory and then at an independent, third-party short-circuit test laboratory (more than 50 fault tests)





Test Results (extract)





Newhaven Town Substation (at outset)

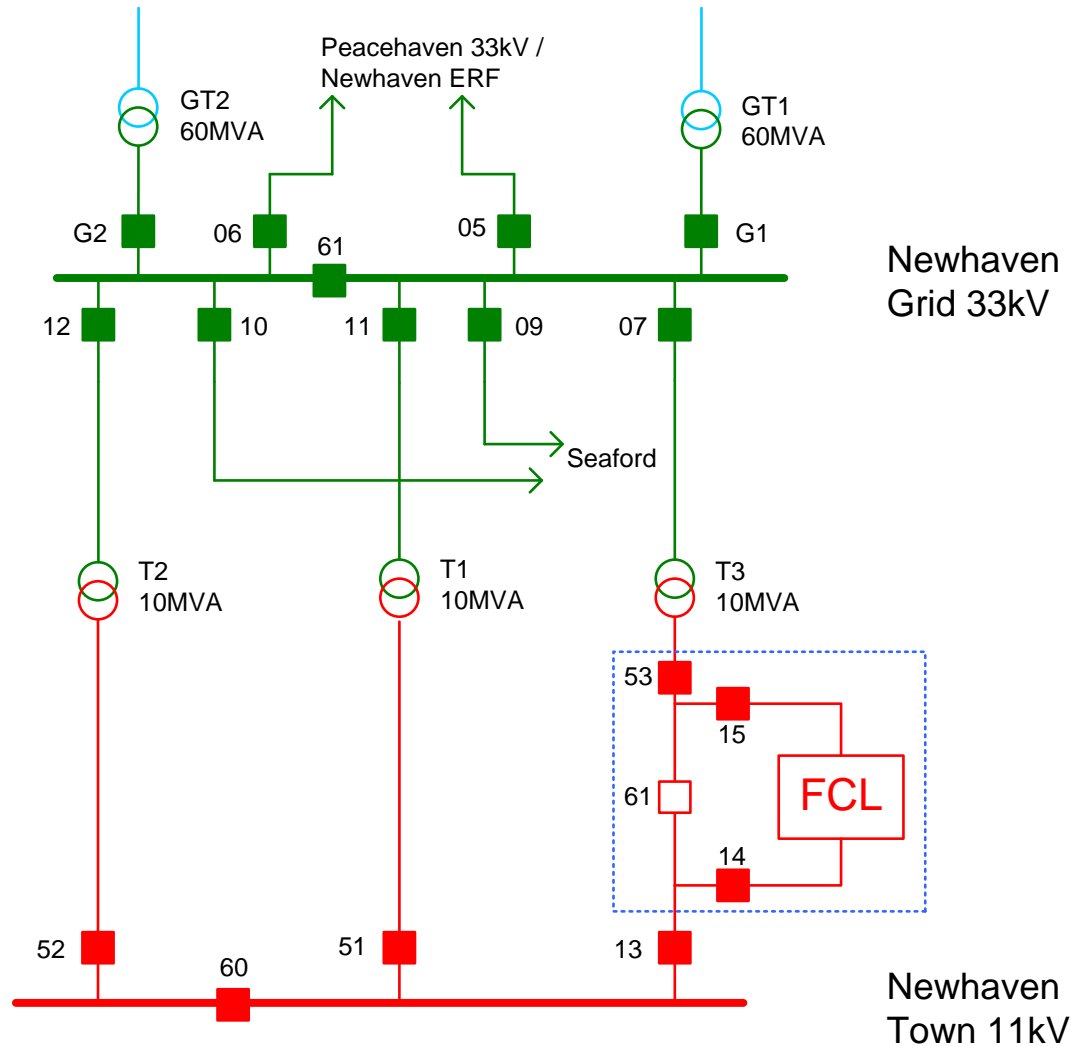
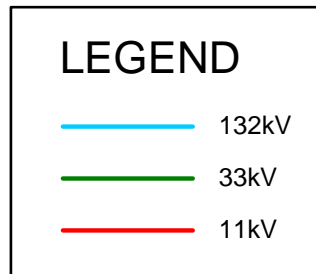


- Newhaven Town Substation (33/11kV Primary substation), East Sussex, UK
- Plan for site works to include new flood defences (under a parallel UKPN project) as well as plinth for FCL and complete new switchroom building for future site flexibility





Newhaven Electrical Schematic





Newhaven Town Construction: Dec 2012





FCL Shipment from Australia to Newhaven





FCL Installation





FCL Installed





Newhaven Town Construction: June 2013





Commissioning

- FCL commissioned into service at Newhaven in May 2013



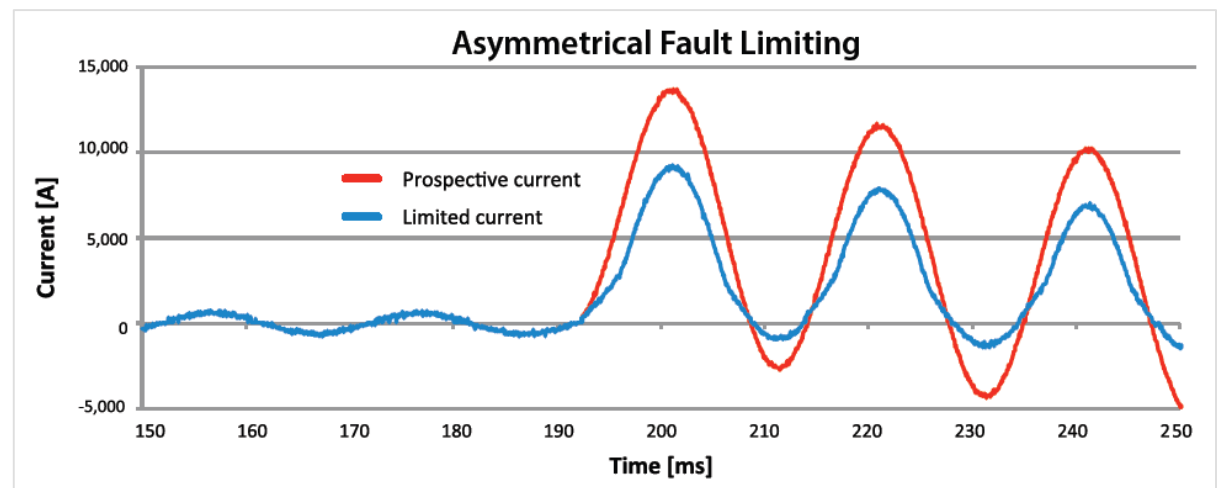


OPERATIONAL EXPERIENCE



Network Faults

- Since the winter storms died out, **five network fault events** have been experienced by the FCL to date (on three separate days)
 - All were cable faults, three on UKPN's network, two on the nearby connected private network at Newhaven Docks
- 5 faults during first 15 months of site operation, follow more than 50 tests in lab:
 - FCL performed **reliably** and **exactly to specification**
 - Faults **limited by up to 46%** (this varies with exact nature of fault)
 - Network and its protection systems behaved as expected
- Example test data:





Second Year of Operation

- Operational Review and Stage Gate held 22nd May 2014, at end of 1st year of demonstration
 - Demonstration very successful to date
 - Crucially, demonstrated **perfect reliability** throughout the first year of operation, under both normal and fault conditions, even through the winter's extreme weather conditions
 - Fault limiting on each occasion **exactly as specified and designed**
 - Proceed with planned 2nd year of demonstration (to mid 2015)
 - Site reconfigured to run all three transformers in parallel
 - an improvement in customers' security of supply that was impossible without the FCL
- *“The FCL is making a real difference to the supply security at the site by allowing the additional transformer operation without exceeding the site fault level limits”*
(Low Carbon Project Manager, UKPN)





Plans for Post-Demonstration Testing

- At completion of 2nd year of operation (mid 2015), FCL will be removed from Newhaven site
- Minor site reconfiguration works
- Further testing of FCL at independent test facility, potentially including:
 - Limited disassembly and inspection to assess condition
 - Further characterisation tests
 - Testing to establish ultimate FCL capability limits (potentially destructive testing)



EXPLOITATION



Commercial Position for FCL Sales by GridON

- Demonstration:
 - provides real evidence of benefits of FCLs to network operators, generators and others
 - justifies confidence to deploy GridON's commercially-available FCLs now as part of business-as-usual activities
- Launch event at start of operation well attended by DNOs and other stakeholders
- Press releases issued at kick-off, at launch event, and in July after first year of operation
- First GridON FCL sale: to WPD for LCN 'FlexDGrid' project
 - "FlexDGrid is a £17 million project which will revolutionise the power network in Birmingham. The WPD initiative will use ground-breaking new solutions to accommodate more low carbon generation across the city, reducing power cuts and helping Birmingham reduce its carbon emissions."
- GridON receiving sustained interest in further potential sales worldwide for both distribution and transmission applications



Other Planned Activities

- A number of activities planned to maximise deployment volumes and speed
- Market Analysis
- Supporting development of FCL standards
- Potential opportunities for further work
 - Opportunities to support next development steps – targeted engineering to reduce unit size, weight & cost, (across product range and of particular importance for distribution applications)
 - Transmission application demonstration
- Engagement with key stakeholders
 - DNOs, TSOs, consultancies & engineering contractors, finance and investment companies, government & regulators, local authorities, academic networks, etc



Further Information

- Further information available:
 - 2 press releases
 - FCL information sheet
 - GridON's data sheet
 - other resources on request
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PCFCL – building on project success





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