

Highlights



- Shetland is the largest islanded power system in the UK
- The innovative project "Northern Isles New Energy Solutions" (NINES) by SSEN trialled Active Network Management, energy storage, domestic demand side management and flexible generation contracts
- Type IV Wind Turbine Generators (WTGs) offer an additional degree of flexibility to the power system
- The legacy of NINES has trebled the total renewable generation capacity to over 12MW, which accounts for a total wind penetration of 20% in 2017-18



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2

Shetland: Background Information



- Largest islanded power system in the UK
- Shetland's power system supplies a population of 23,000
- SSEN is the System Operator
- Maximum / Minimum demand: ca 45/12 MW
- Average wind capacity factor: 52%

Modelling and Analysis Results

- No more firmly-connected large wind generation could be connected
- BAU connections for renewables limited to 3.68kW/phase



Source: Wikipedia

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3

NINES



Overview

- Led by SSEN
- £34m funding from Ofgem, DECC and Hjaltsland Housing Association
- Duration: November 2011 – December 2016

Objectives

- Reduce reliance on fossil fuel consumption
- Evaluate how an isolated system could be securely operated with a high penetration of renewable generation

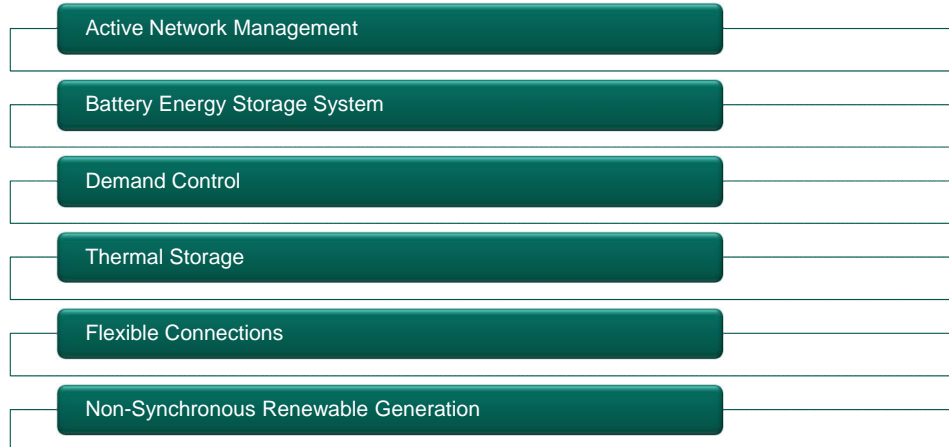


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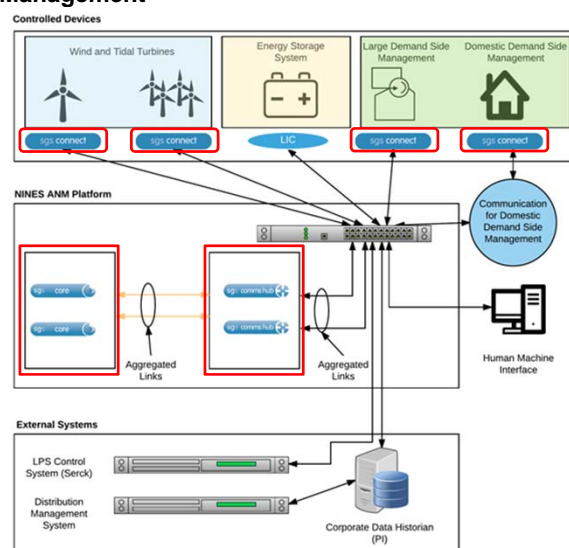
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4

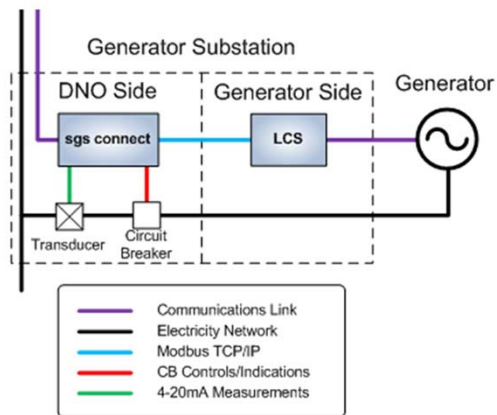
Smart Grid Elements



Active Network Management

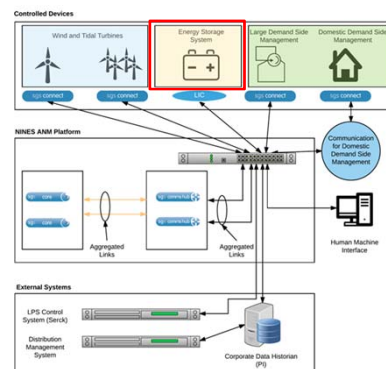


Active Network Management



Battery Energy Storage System

- Valve Regulated Lead Acid modules
- Rated power: 1MW
- Energy rating: 3MWh
- Aimed at: load shifting
alleviating renewable constraints

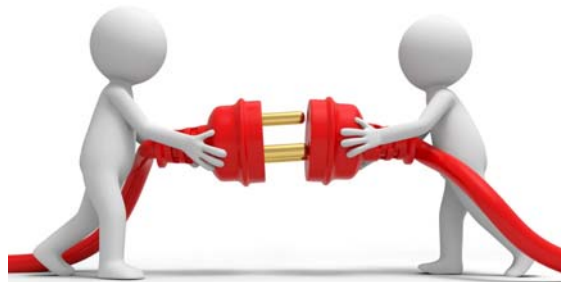


NINES



Flexible Connections

- Output of new generation might be curtailed
- No financial compensation
- No guaranteed level of grid access
- Curtailment assessment as part of the Connection Offer
- “Last in, first out” principle of access
- Total accepted capacity of 8.55MW



Source: Sellleadsuceed.com

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9

NINES



Renewable Generation With NINES



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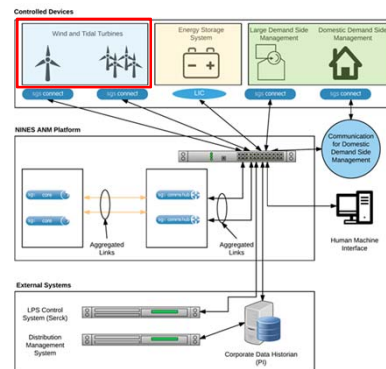
10

NINES



Non Synchronous Renewable Generation

- North Hoo WPP: 1 x ENERCON E-44
0.5MW / 0.63MVar
- Gremista WPP: 1 x ENERCON E-82 E4
3MW / 2.3MVar
- Garth WPP: 5 x ENERCON E-44
0.9MW / 0.63MVar



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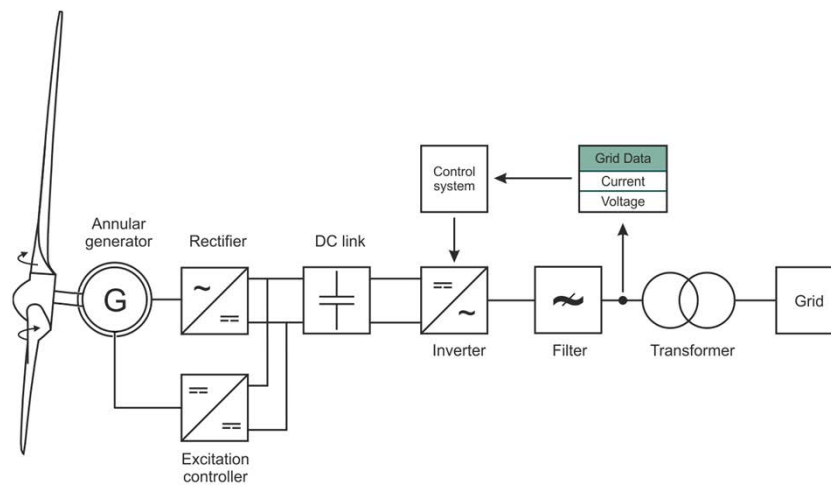
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11

NINES



Type IV Wind Turbine Generators

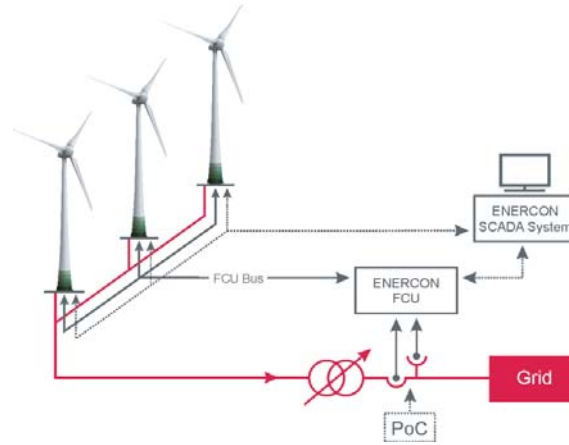


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12

WPP Control



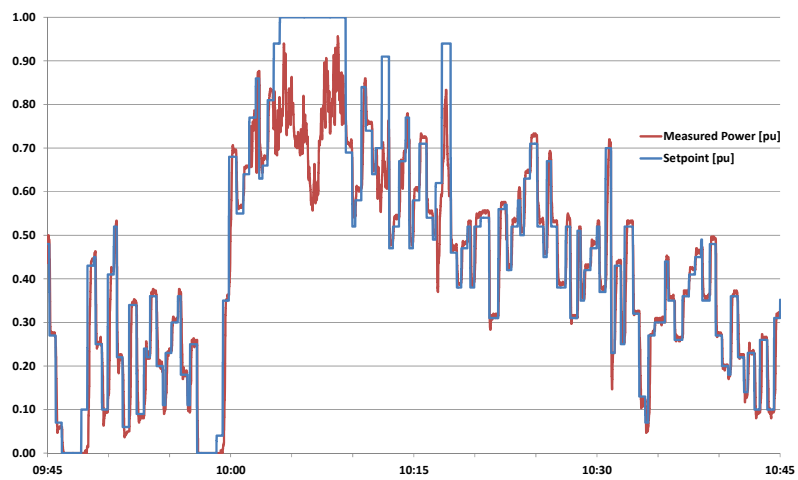
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13

NINES – Results

Active Power Response



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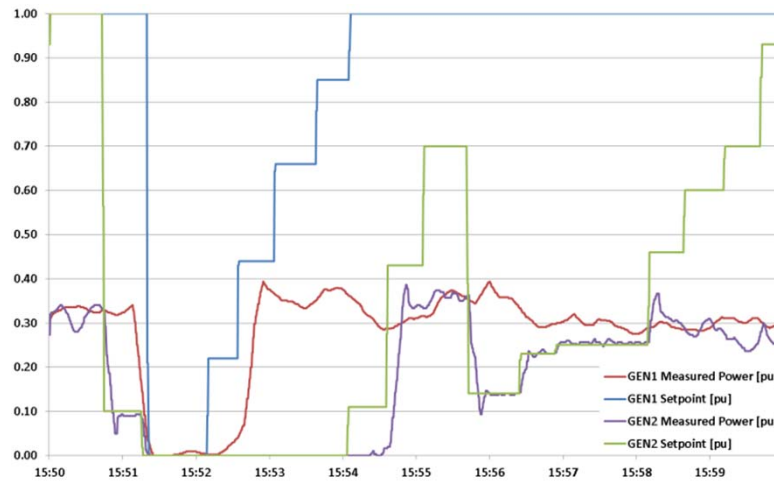
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14

NINES – Results



Active Power Response



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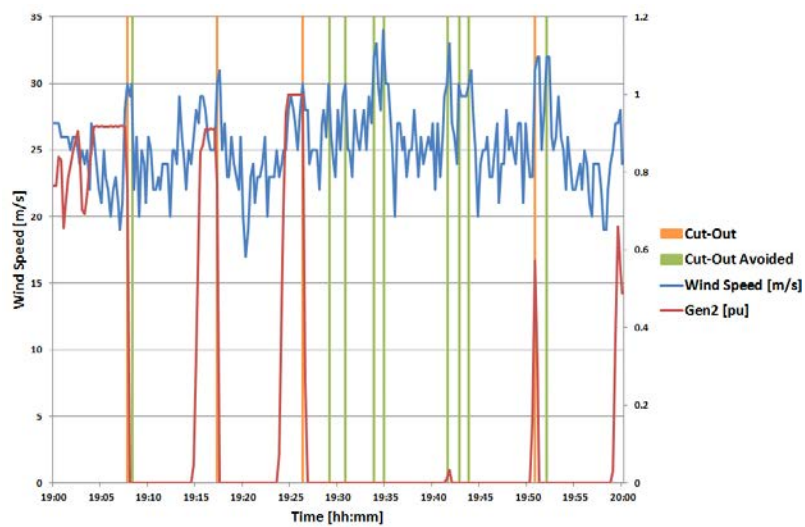
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15

NINES – Results



Management of High Wind Speed Events



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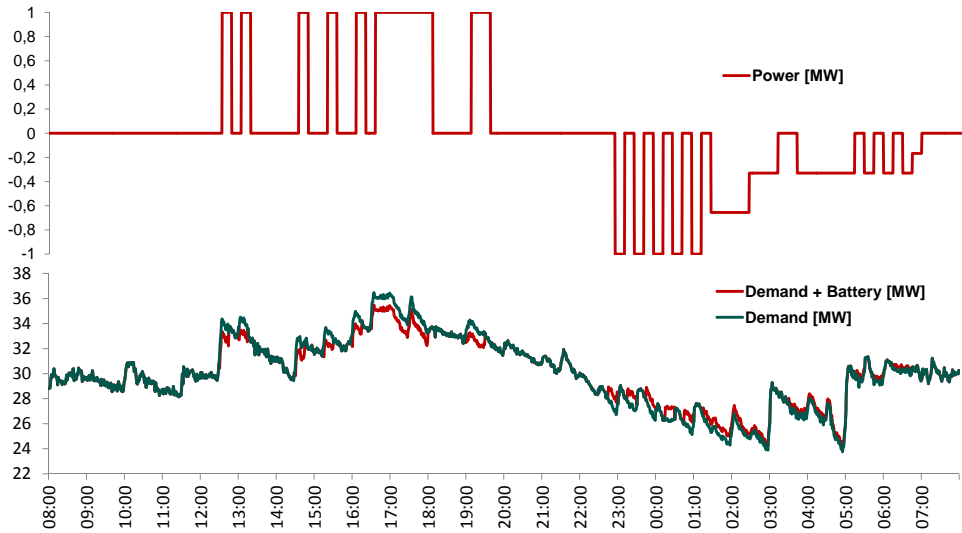
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16

NINES – Results



Performance of The Battery Energy Storage System



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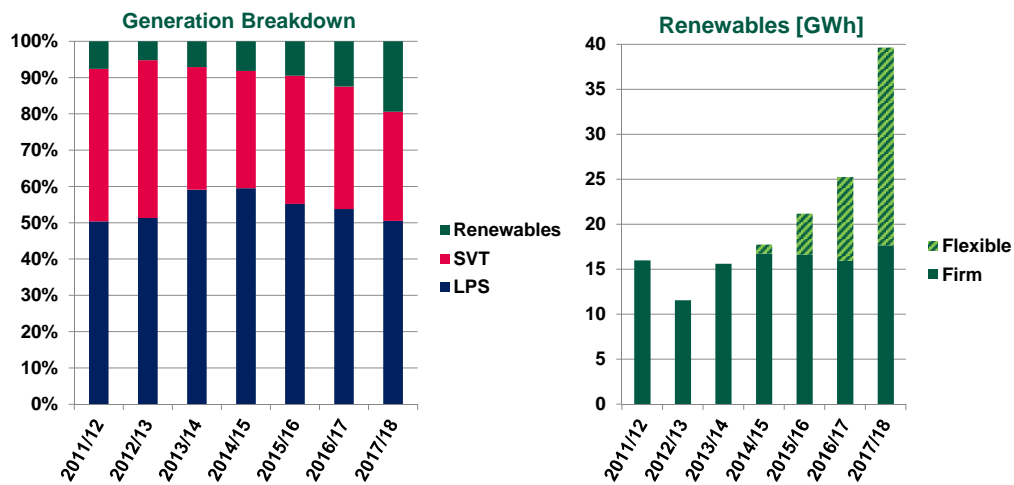
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17

NINES – Results



Wind Penetration



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18

Conclusions – Outlook



- Shetland offers an excellent case-study for the conditions likely to be encountered in more complex systems
- NINES trialled for the first time in the UK a smart grid including an ANM capable of controlling generation and demand sources, as well as a battery energy storage system
- Type IV WPPs are well suited to contribute to the stable operation of non-interconnected systems
- HVDC interconnector to mainland considered
- Major upgrade to the ANM expected to be completed in Q2 2018



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19



Turn barriers
into
climbing walls

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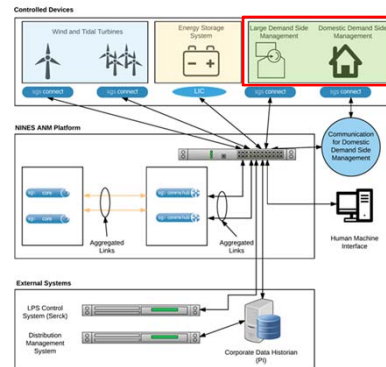
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20

Northern Isles New Energy Solutions (NINES)

Demand Control and Thermal Storage

- 234 next generation storage heaters / hot water cylinders
- 4MW electrical boiler linked to a thermal store capable of storing around 135MWh of hot water



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21

Shetland: Prior to 2014...



Three Main Generation Sources

- Lerwick Power Station: 67MWe oil-fired plant
- Sullom Voe Terminal: gas power station, 5-15MW can be exported during normal operation
- Burradale Wind Power Plant: 3.68MW type II WPP

Modelling and Analysis Results

- No more firmly-connected large wind generation could be connected
- BAU connections for renewables limited to 3.68kW/phase



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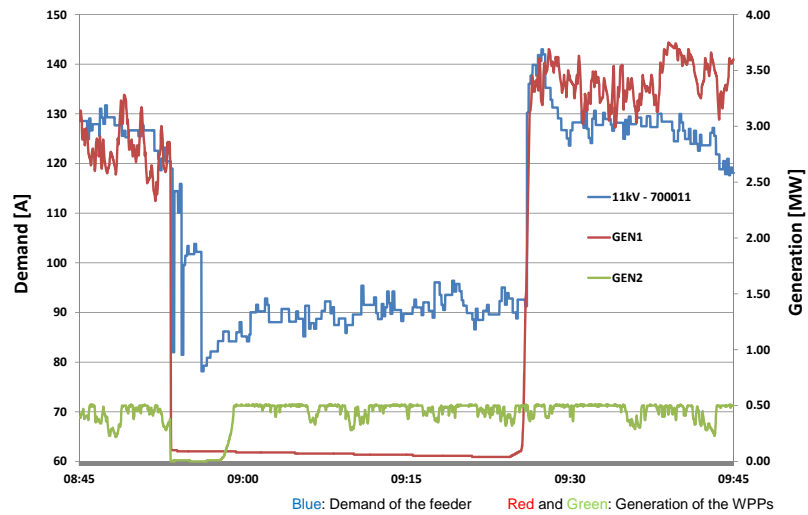
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22

NINES – Results



Resilience to Faults – Before



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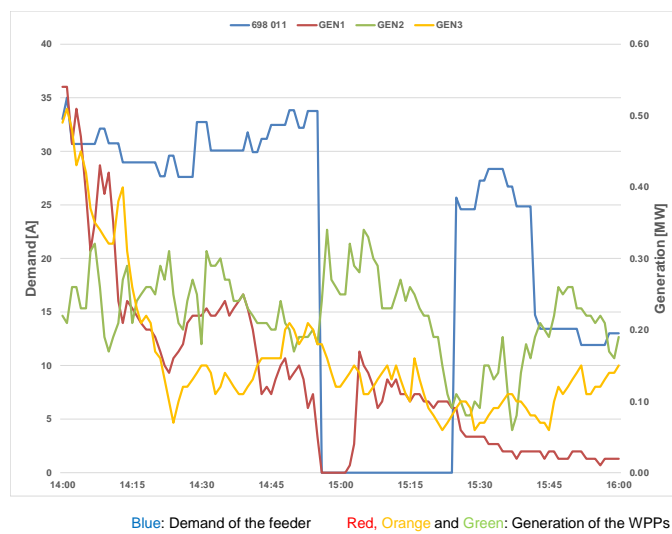
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23

NINES – Results



Resilience to Faults – After



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24

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