Senergy Econnect

Energising Renewables

Wind-Diesel Experience on Scottish Islands

Ottawa Wind Diesel Conference June 2009

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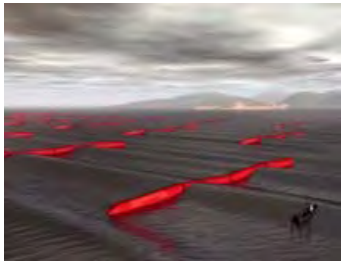
Technical & Business Development Director

Agenda

- Senergy Econnect business and clients
- Foula island first system
- Foula refurbished system
- Eigg
- Kisiizi
- Summary

Senergy Global

Senergy Products & Services

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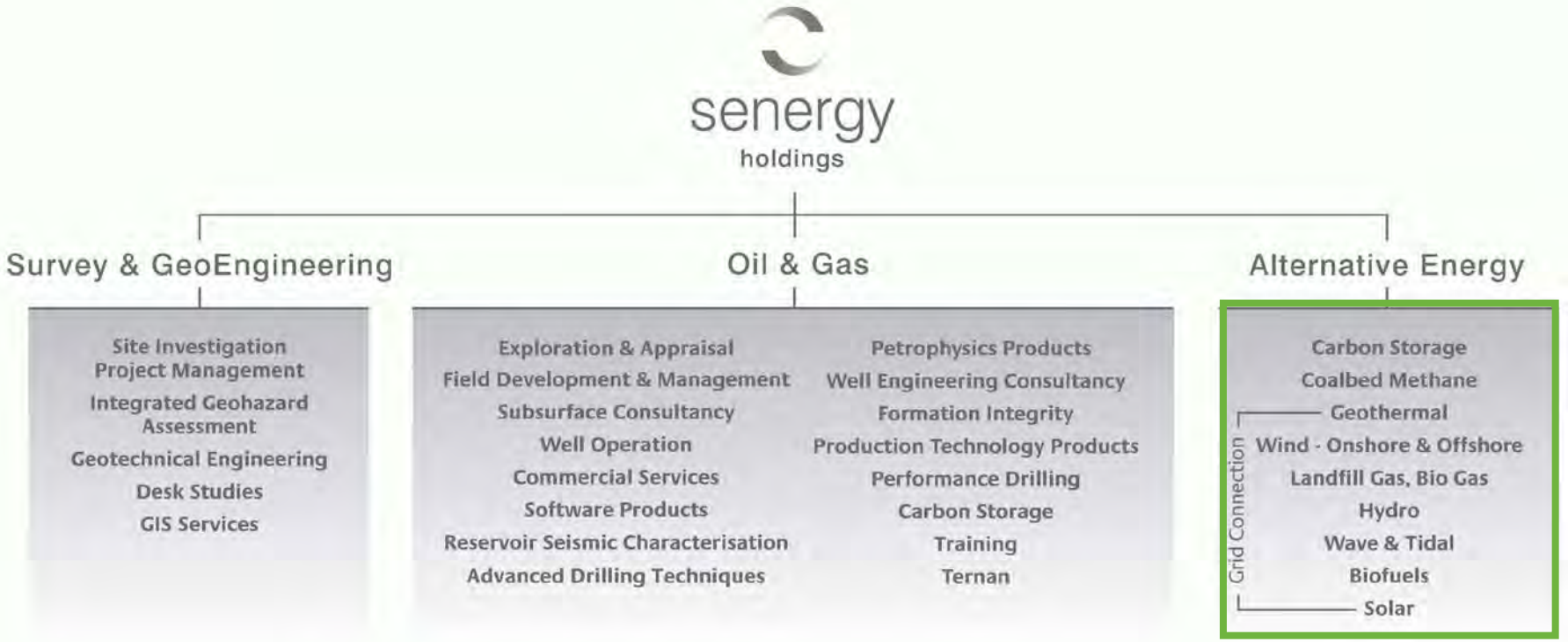


Technical Disciplines

Reservoir Engineering
Well Engineering
Production Technology

Geology
Geophysics
Geomechanics

Carbon Transport & Storage
Petrophysics
Software Design & Engineering

Rock Physics
Electric Engineering

Technology

ODM3™
IP™
Eikos™

GenAVC™
powaplug
www.gridconnection.co.uk

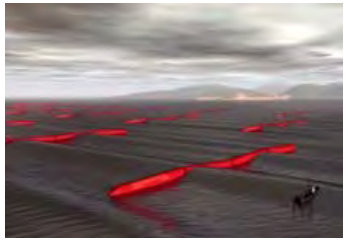
Senergy Econnect - summary

- International consultants and advisors in renewable energy and grid integration.
- 14 years in renewables
- Contracts in over 30 countries.
- Involved with half of wind turbines installed in UK.
- SmartGrids.

Senergy Econnect - Client Base

Senergy Econnect - Technologies

- Wind
- Tidal
- Biomass
- Biogas
- Energy from Waste
- Hydro
- Concentrating Solar Power (CSP)
- Solar thermal
- PV
- Diesel/ Biodiesel
- Landfill Gas
- Wave
- Co-Gen/CHP



Foula – Location

Foula:

20 miles from Shetland

2.5 miles

Foula – in 1980s

- Foula in mid 1980s
  - Remotest inhabited island in British Isles ~ 50 residents.
  - Crofting economy.
  - Poor transport links.
  - National Nature Reserve;
    - ~2million birds.
- Infrastructure upgrades planned

  New Harbour.

  New School.

  Electricity Scheme.

Foula – electricity scheme plan

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- 1983 Project planning & feasibility
- 1983/4 Funding application
- 1985 European part funding awarded
- 1986 Shetland Island Council funding
- 1986 Scheme design, specification and planning
- 1987 Procurement and installation
- 1988 Phase 2 and commissioning
- 1989 Full commissioning and handover of scheme

Foula – original layout

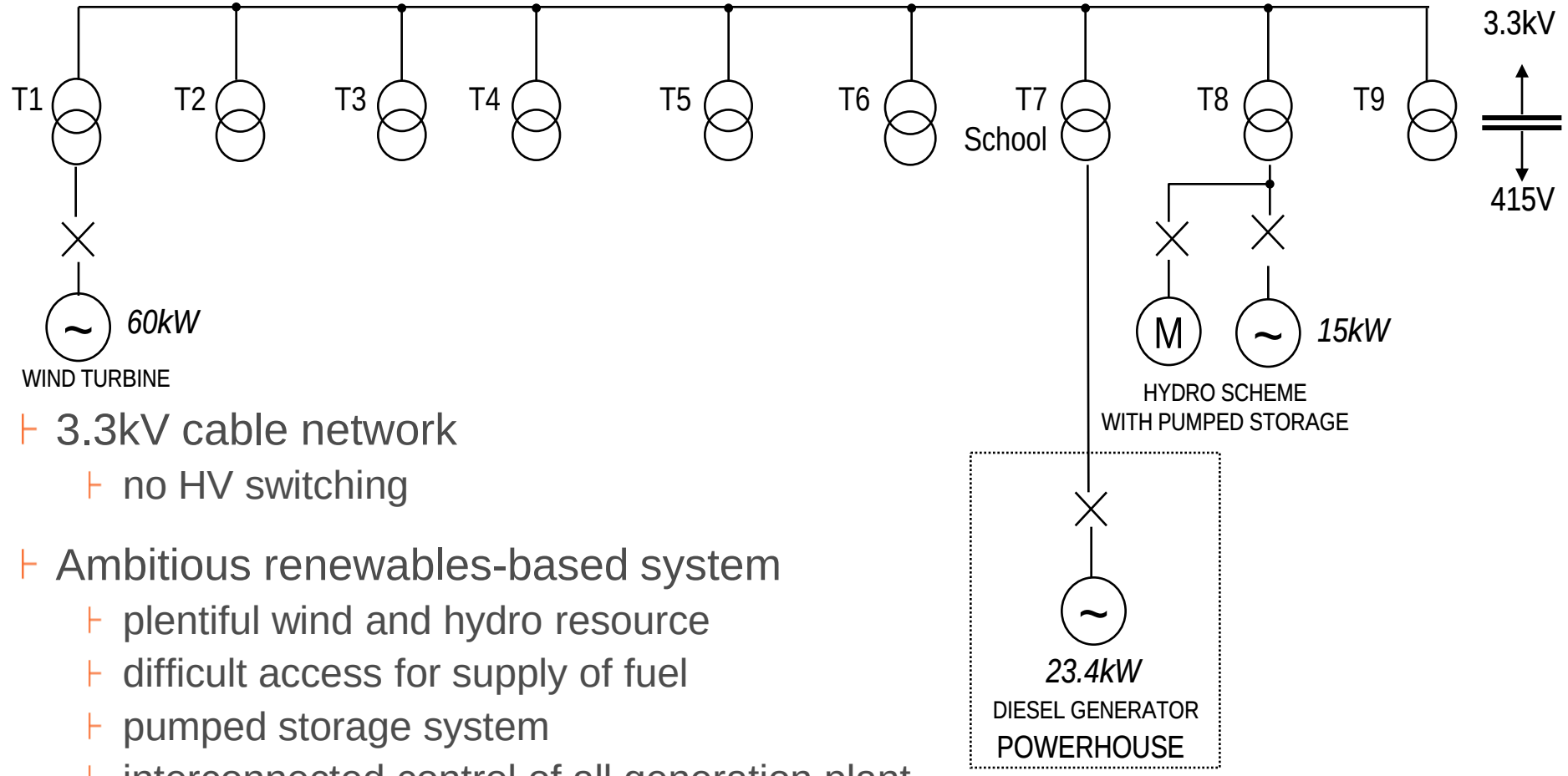
transformer

hydro turbine, pumped storage and pipeline

diesel generator

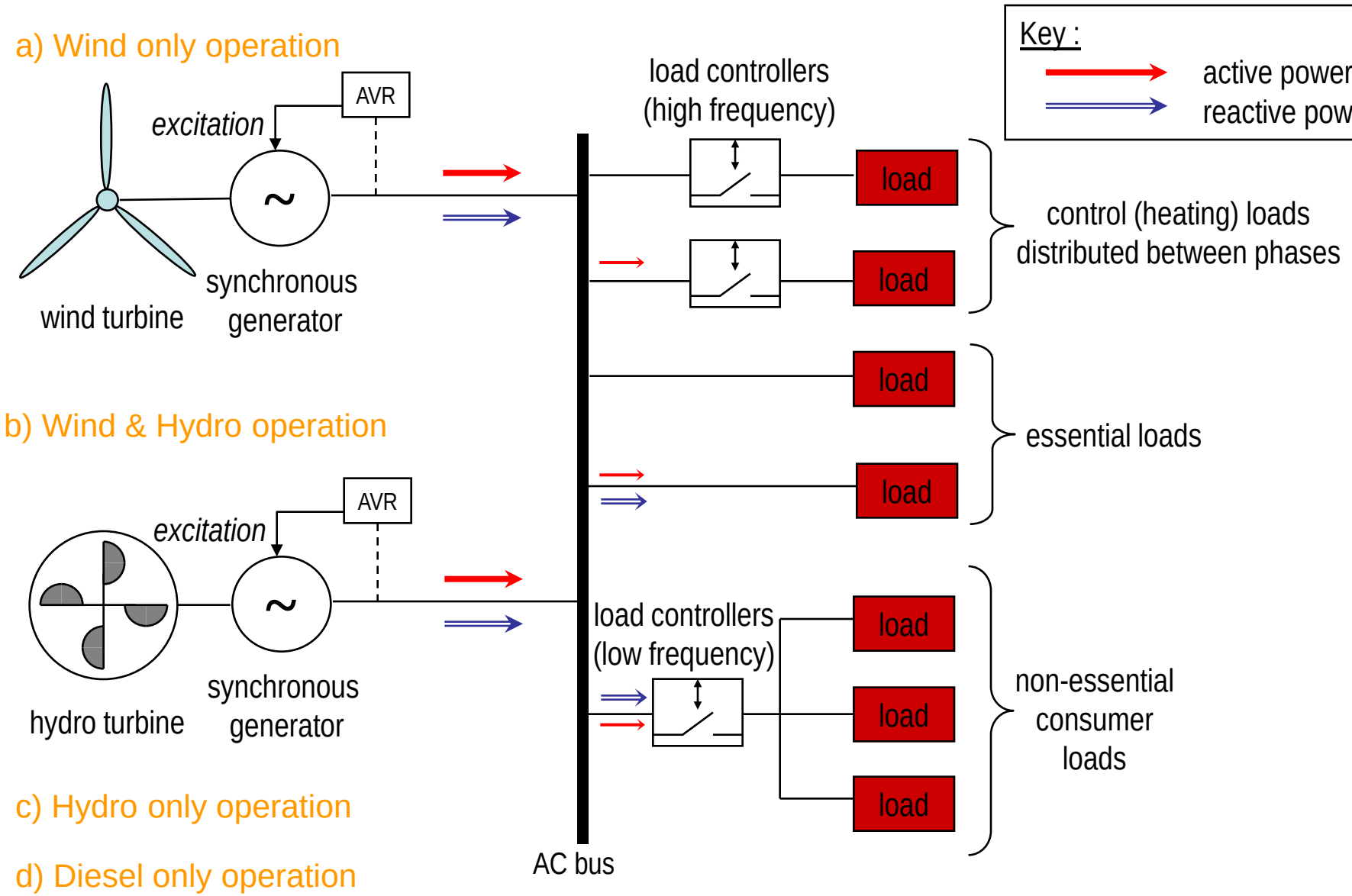
wind turbine

Foula – original schematic



- 3.3kV cable network
  - no HV switching
- Ambitious renewables-based system
  - plentiful wind and hydro resource
  - difficult access for supply of fuel
  - pumped storage system
  - interconnected control of all generation plant
  - autonomous demand-side management
  - diesel generator back-up

Foula – original system operation



Foula – positive aspects 1/2

- “smart” metering with 3 tariffs:
  - High for diesel;
  - Medium for renewable power;
  - Low for heating loads.
- Hydro
  - Had induction generator as well as synchronous generator for rapid start up and injection of power prior to synchronisation.
  - Spear valve control allowed water conservation.
  - Supported wind power in turbulent conditions (lulls in wind output) without needing to start diesel.

Foula – positive aspects 2/2

- Demand side management to:
  - Add heating load using spare energy;
  - Shed & Shift non critical loads during power shortages.
- Computer/software based supervisory control scheme:
  - Allowed operational improvements to be made with experience.
- 3.3kV HV distribution scheme:
  - No HV switchgear, one point of protection with inter-trips, very reliable.
- Community:
  - Bought into scheme and became strong supporters.

Foula – areas for improvement 1/4

- Hydro & pumped storage:
  - Hydro scheme fell short of design power
    - About 12kW compared to 20kW design;
    - Was too small to carry community load.
  - Hydro catchment very small
    - Larger catchment available without storage.
  - Loch subject to wind waves > silt and debris
    - Pelton runner was badly warn by high sand content;
    - Debris (peat and turf) blocked trash rack.
  - Pumps too large loads (2.5, 7.5 and 7.5kW)
    - Needed variable speed drives for soft starting and control.

Foula – areas for improvement 2/4

- Control and monitoring system
  - User interfaces
    - Before the days of GUI and touch screens;
    - Re programming and reloading a skilled role.
  - Generator controls
    - Did not use Programmable Logic Controllers;
    - Based on complex relay logic schemes;
    - Fault finding, diagnostics and control logic very complex and difficult.
  - Remote monitoring
    - No remote communications or interfaces at the time.
  - Demand side management
    - Load shed/shifting was circuit based;
      - appliance based would have been better.
    - Randomised shed/shifting (not a fixed order).

Foula – areas for improvement 3/4

- Wind turbine
  - Scheme was over reliant on a single machine.
  - Turbine was a “special” with synchronous generator could not be easily replaced or duplicated.
  - Proportional frequencyt load governing control scheme only allowed full output in very high winds. Output did not reach rated except to power dump load.
  - High turbulence from 1000ft cliffs gave highly variable outputs.
  - Needed to be shut down in turbulent wind speeds and directions.
  - Severe marine environment and difficult maintenance.

Foula – areas for improvement 4/4

- Community
  - Initially were not on board;
  - Resident turnover during project timescales;
  - Insufficient skills to maintain all various aspects;
  - Trained individuals moved on;
  - Too complex except for intermittent role.
- Corrosion Protection / finishing
  - Very aggressive marine environment.
- Health and safety
  - System operation and maintenance by islanders would not be acceptable today.

Foula – original operation

- After 10 years of operation:
  - Wind turbine electrical generator failed and was not replaced.
  - Hydro scheme unreliable and low output.
  - Scheme running wholly on diesel power.

Foula refurbishment & options

- Driven by deterioration of old system.
- In 2004 3 options investigated in study costing 29,375GBP:
  - Connection to Shetland Islands grid (diesel powered with wind support) 4.5m GBP.
  - Provision of battery storage unit with upgraded diesels and network. Capital cost not stated. Annual costs ~25k GBP subsidy to maintain parity with Shetland power prices.
  - Provision of an upgraded hydro, pv and wind scheme budgeted at 1m GBP.

Refurbish scheme funding

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- Scheme cost 833,000 GBP:
  - Shetland Islands Council
  - Shetland Enterprise (40,000)
  - Highlands and Islands Community Energy Company (80,000)
  - European Regional Development Fund (355,233)
  - Energy Saving Trust
  - Big Lottery Fund (200,000).

Foula refurbished scheme location

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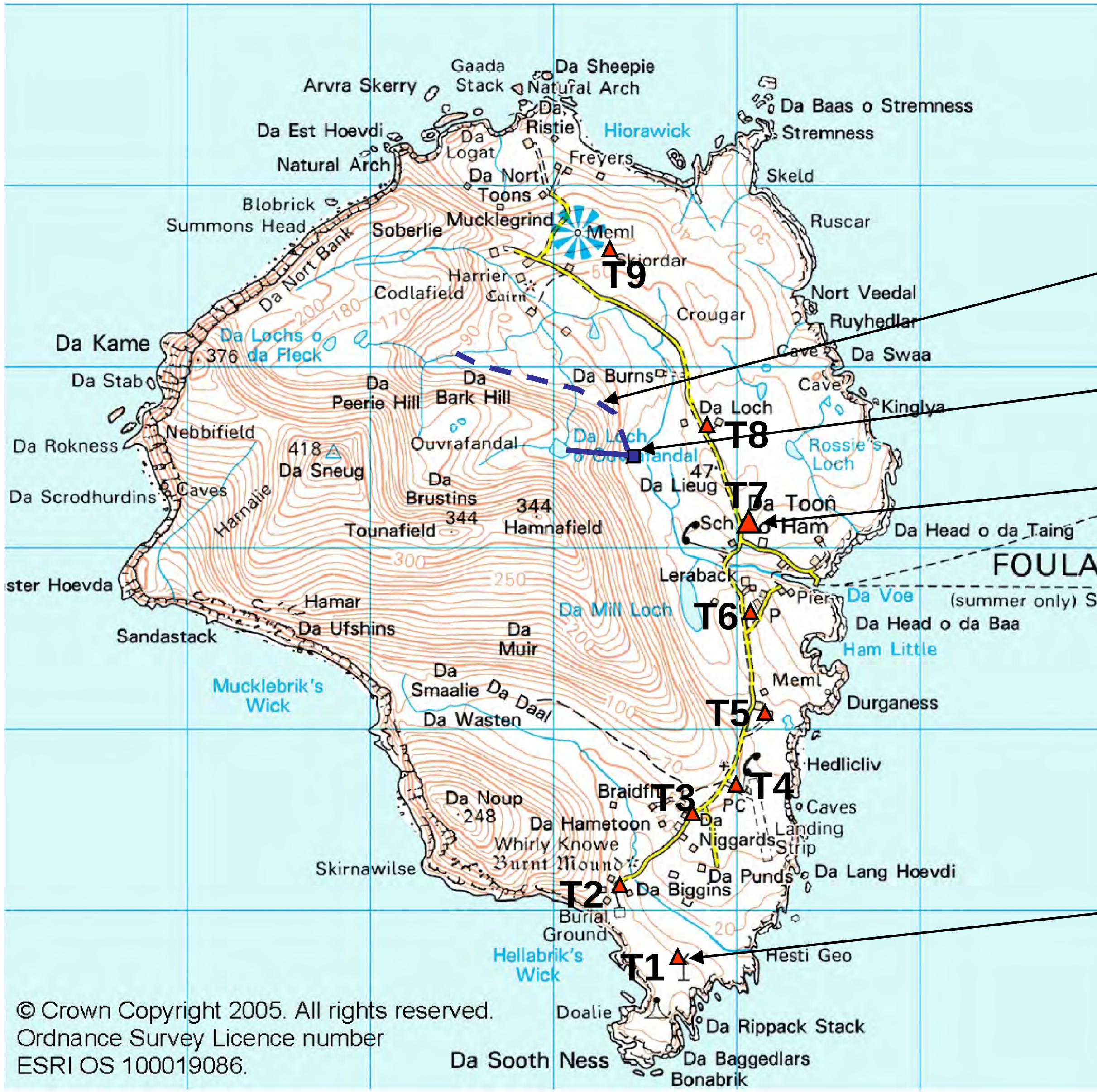


▲ transformer

new pipeline

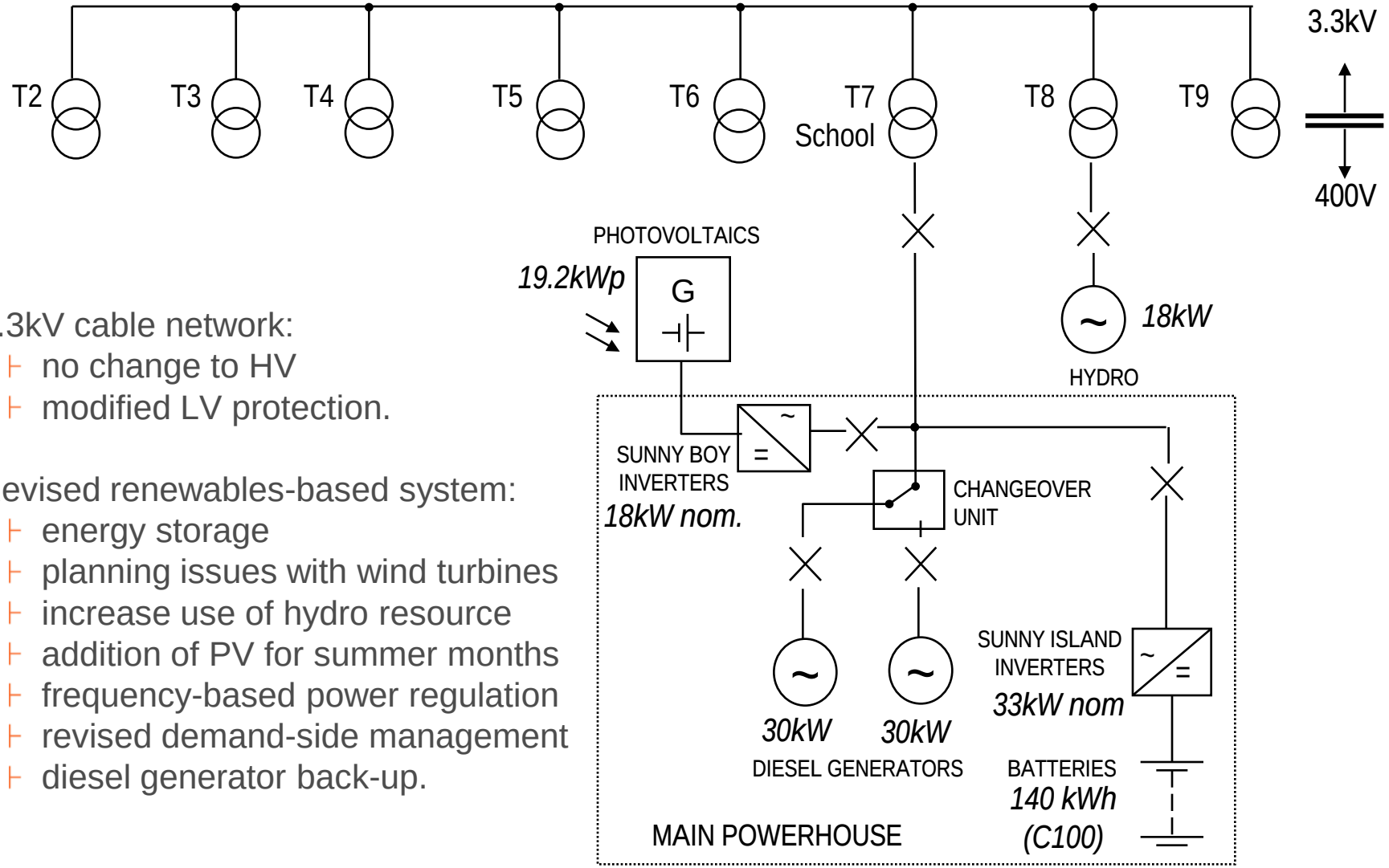
existing hydro turbine and pipeline.

batteries and inverters
2 x diesel generators
PV array

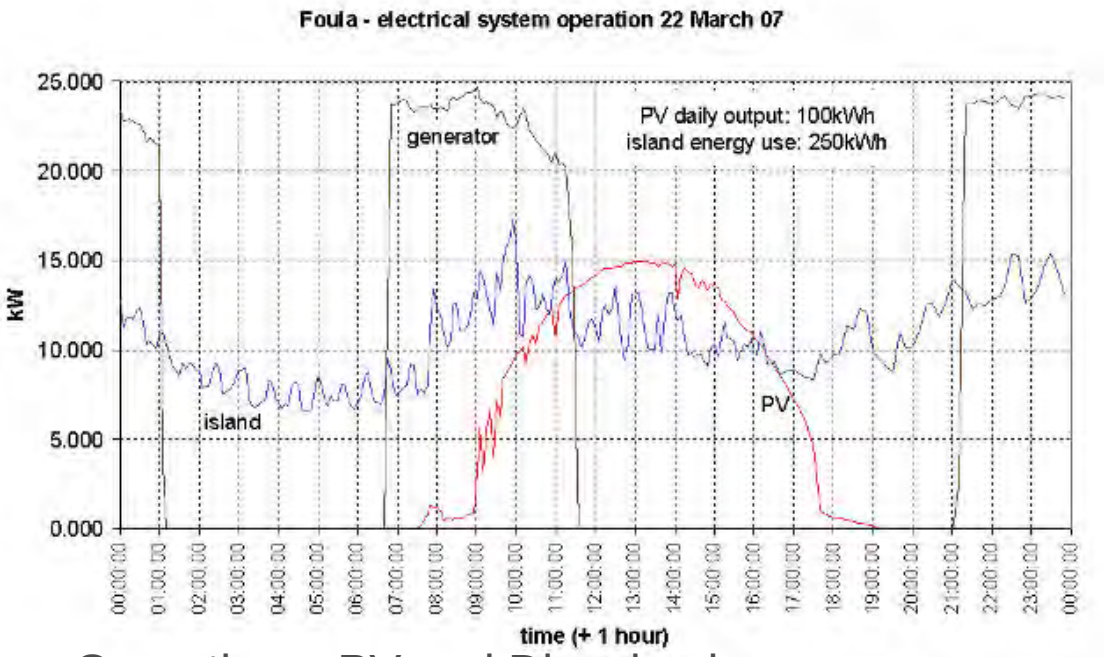
defunct wind turbine transformer T1 disconnected

Foula refurbished scheme design

- 3.3kV cable network:
  - no change to HV
  - modified LV protection.
- Revised renewables-based system:
  - energy storage
  - planning issues with wind turbines
  - increase use of hydro resource
  - addition of PV for summer months
  - frequency-based power regulation
  - revised demand-side management
  - diesel generator back-up.



Foula – refurbished operation



Operation – PV and Diesel only

Photos courtesy of Wind and Sun Ltd

Eigg

- No existing electrical network.
- Community buyout of island 1997.
- Consultation and feasibility study 2003.
- Outline design and budget by Senergy Econnect in October 2004.
- Funding obtained; design contract awarded May 2006.

- Characteristics
  - similar to Foula - more residents (72 properties), longer distances (5 miles x 4 miles).
  - more generating sources (hydro, wind, PV) including existing hydros.
  - large hydro installation at Laig (100kW).
  - budget to cover complete network installation.
  - agreed limit on domestic supplies (20A).

Isle of Eigg

Eigg Hardware

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Scheme cost 1.5M GBP

Generating Feb 2008

Photos courtesy of Wind and Sun Ltd

Kisiizi Uganda

- Hydro mini-grid system.
- Power blackouts in 2001.
- Senergy Econnect retrofitted load / demand side management.
- Operating to date.
- More power sold, better quality of supply.

Summary

- Senergy Econnect experienced in Wind Diesel schemes and Hybrids with PV and Hydro.
- Experienced in the design, analysis, implementation and commissioning of schemes:
  - Scotland: Foula, Eigg, Muck, Rum, Knoydart, Fair Isle.
  - Elsewhere: Uganda, Greece, Greenland, St Helena.
- Lessons learnt from refurbishment of Foula and ongoing refurbishments and improvements on Rum, Fair Isle, Knoydart, Muck, St Helena.
- Extensive use of demand side management solutions.

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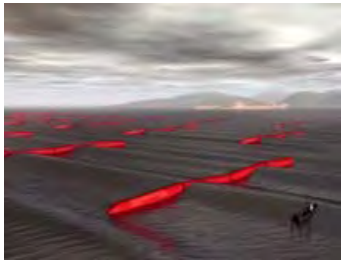

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