Rural Energy Grant Scheme Large Farm Power Systems -A Different Approach

FALKLAND ISLANDS
DEVELOPMENT CORPORATION

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Falkland Islands

Figures and Statistics

Land Area	11650km²
Population	2913 (2001)
Climate	Cool Temperate
Temperature range	0 C to +14 C
Annual rainfall	600mm
Average wind speed	8m/s

Centred on 52° South 59° West

Falkland Islands Development Corporation

Commercial division of the Falkland Islands Government

To encourage and assist all aspects of local business.

- Industry, agriculture, construction, fishing, retailing etc.
- Financial assistance and services
- Practical business plans and assistance
- Cost saving measures including energy
- Import substitution

Energy Distribution

- Stanley Power Station 6.6MW
  - Provides energy for Stanley area only
  - No firm plans for wind power as yet
- No Island-wide power grid system
  - Population scattered too widely
- Around 100 farms with off-grid power
  - All have diesel generators
  - Most settlements have a central power source

Original Project Strategy

- Install battery inverter systems
  - Reduce diesel generating costs
  - Provide 24 hour power
- Use wind turbines to charge batteries
  - Minimise diesel generating costs

  - Improve electrical safety standards (Grant assistance)
  - Ease capital costs to farms by offering a Grant in two stages
  - Simplify maintenance by promoting standard range of equipment
  - Collect data for future development

Installation Summary

- Systems installed at August 2002
  - 3 or 4.2 kW systems (battery inverter only) 5
  - 3 or 4.2kW systems with Proven Turbine 50
  - 20kW system (Pebble Island) 1
  - 9kW system with 6kW Proven Turbine 1
  - 9kW system with twin 2.5kW Proven Turbines 1
  - 4.5kW systems installed privately 4
  - 3kW systems installed under Extension Scheme 2

  Total systems 64

- Systems planned for 2002-3
  - 3 or 4.2kW systems with Proven Turbine 8
  - Large settlement systems 4

Where do we go from here?

Large Farm Systems

Targets

- Reduce Rural electricity generation costs
- Provide 24 hour electrical power

Standard large farm power set up

- Mini grid with central diesel generator 30 to 90 kW
- Typical grid power demand between 5 and 30 kW

Not economic to install Trace/Proven systems

Large Farm Systems

Original plan

Large central inverter, battery and wind turbine

Problems

Sourcing equipment

- No suitable equipment from Europe (3 year search).
- Equipment must be from Europe (Stabex Funding rules)

Reliability

- Experiences with large inverters not reassuring.

Conclusion

- Market not interested in producing suitable equipment
- European manufacturers too busy with 1.5 – 4.5MW monsters.

Options for 24 hour power

1. Continuous diesel generator operation
   - Not a economical option under this programme.
   - No renewable option.
   - Wind turbine addition will reduce efficiency of diesel generator.

2. Central large battery inverter system (15-30kW)
   - Fears over reliability, repair expertise, cost of spares holding
   - High capital cost. (All eggs in one basket)
   - Social concern and conflict over misuse.

3. Distributed storage system (3-6 kW)
   - Modular 24 hour power. Shifts power management to user.
   - Renewable option difficult. (Development in progress)
   - Higher overall cost than large single battery inverter system.

Distributed Storage System

Disadvantages;

- Higher final capital equipment cost
- Battery safety and security
- Central power source must be 50 HZ AC 240V 1ϕ
- Any renewable input must be synchronous
- Diesel must be run 4 -8 hours every day
- Non transferable battery and inverter capacity

Distributed Storage System

Advantages;

- Modular system, phased installation
- Easy to maintain.
- System expansion easy.
- Spare inverter can be held on site
- Flexible operation.
- Shifts power ownership to user.
- Potential to improve energy management habits
- Possible for house holders to add turbine or PV
- Immune to diesel generator change over glitches
- Equipment from Europe available now

Distributed Storage System

Phase 1

- Each house has its own inverter and battery system
- Existing diesel generator is primary power source

Phase 2

- Central wind turbine installed as primary power source
- Diesel generator relegated to backup role

Phase 3

- Diesel generator “top up” system to make up short fall

The Human Element

How to make this system work….

- Keep it simple
- Bring people on board
- Let them share in power management

Design

- Oil space heating, gas cookers, energy efficient equipment
- Short term high power devices only (kettle, toaster)
- Scheduled diesel generator operation

Education

- People pay market rate for power
- Turn off things that are not in use. (Risk of a flat battery)
- Risk of power cut if 3kW is exceeded
- Simple indication that diesel or wind power is available

Phase 1 objectives

Objectives

- ✓ Enable 24 hour power.
- ✓ Reduction in generator hours and fuel use.
- ✓ Delegate energy management to user.

Strategy

Install inverter battery systems

3kW inverter with 200 – 400Ah gel battery

Are 3 Kilowatts enough?

2 week mid-winter electrical power survey

- City based fully equipped family house with 24 hour power
- Oil fired heating and LPG cooker
- Dishwasher, washing machine, etc, etc.
- Teenagers!!!

No power restrictions or special rules imposed

- 3 kW exceeded only 8 times (15 minute integration periods)
- 3.5kW maximum power demand

Conclusion

From this survey and experience on existing 3 kW systems.

3 kW should be enough to power a family house

Phase 2 objectives

Objectives

- ✓ Incorporate wind (or hydro) power
- ✓ Minimise diesel generator hours and fuel use

Strategy

- Install central wind turbine
- Synchronous condenser (or other system)
- Electronic control modules with dump loads

Phase 2 Equipment

Gazelle 20kW wind turbine

Designed as a grid connect machine

Research projects

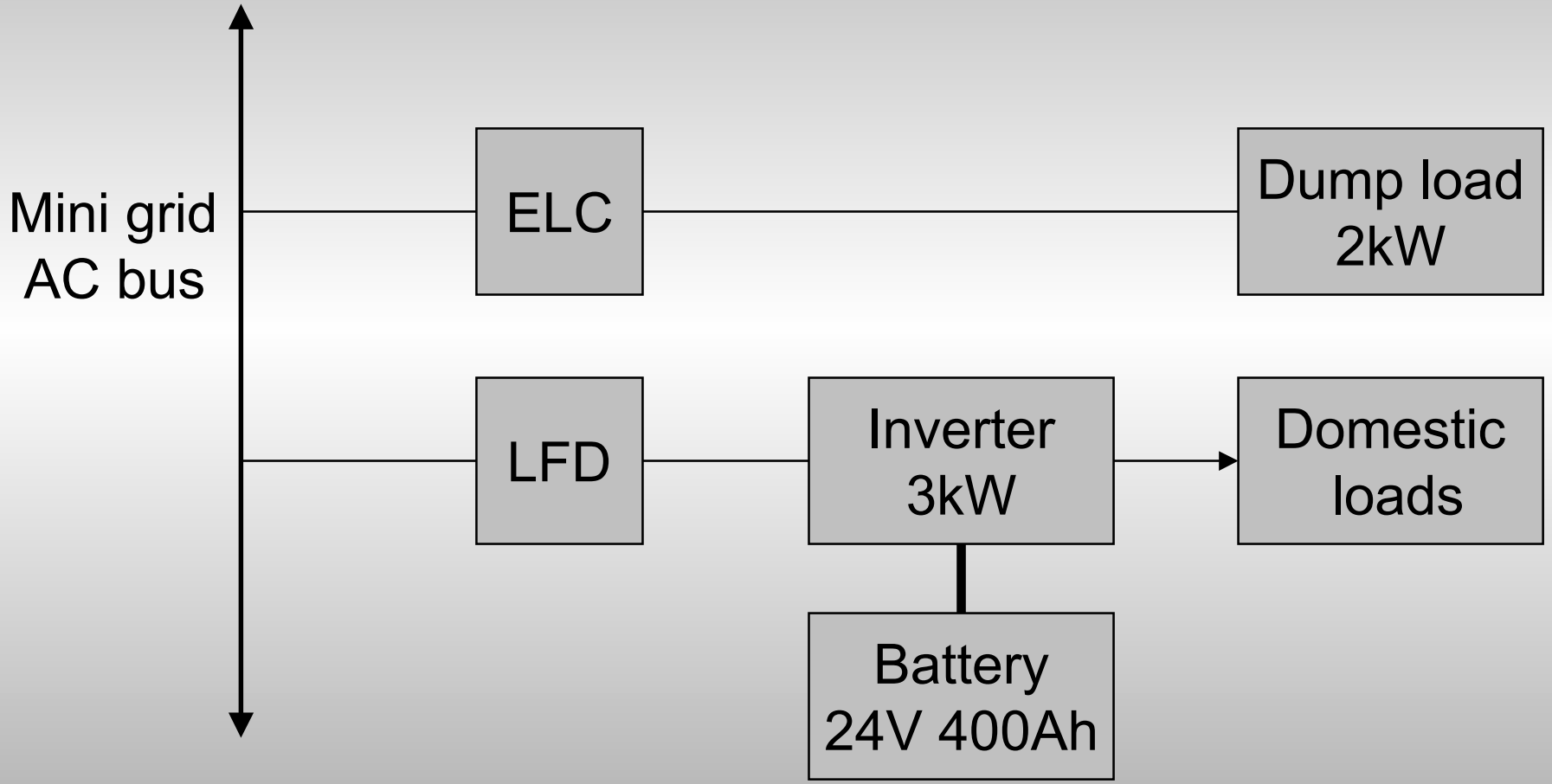
- Econnect (UK) Ltd.
- University of Manchester (UMIST)
- Loughborough University (CREST)

Stand alone operation

- Synchronous condenser
- Other system (see later)

Single phase version

House installation



NB Metering and protection equipment not shown

Maximum Frequency Control

Electronic load control (ELC)

- Distributed fuzzy logic frequency sensitive switches
- Distributed 2kW loads. (Heaters)
- Up to 10 loads (20kW total) for contingency
- Zero crossing switching to reduce noise
- 5 different frequencies from 49.45 to 50.72 Hz

NB. The Diesel Generator output cannot be connected to these units

Minimum Frequency control

Low frequency disconnect (LFD)

- Low frequency disconnect (fuzzy logic) at each inverter AC input.
- Fuzzy logic switching threshold frequency is about 48Hz,
- Houses drawing less than 2.5kW are isolated for 5 –15 minutes.
- Inverter provides power to isolated houses

Without this system, inverters go into charge/invert oscillation at 47Hz

Transparent to diesel generator operation (logic resets at 51Hz)

This approach is a 95% solution and not totally foolproof.

Some fine tuning of the operating parameters would be expected

System operation

3 main modes of operation

- Inverter only
  - Low power demand (night time, afternoons)
- Diesel generator
  - Peak power demand – Timed operation, morning and evening
  - Battery charging in calm weather
  - “Top-up” power management (Phase 3)
- Wind turbine
  - Power on the grid as and when available
  - Battery charging and power supply
  - “Chop back” light load control to optimise renewable input

Phase 3 objectives

Diesel generator

- ✓To make up energy demand and supply deficit
- ✓Contingency in case of calm periods

Phase 3 operation

- Energy metering and daily audit.
- Diesel generator used to make up energy short fall.

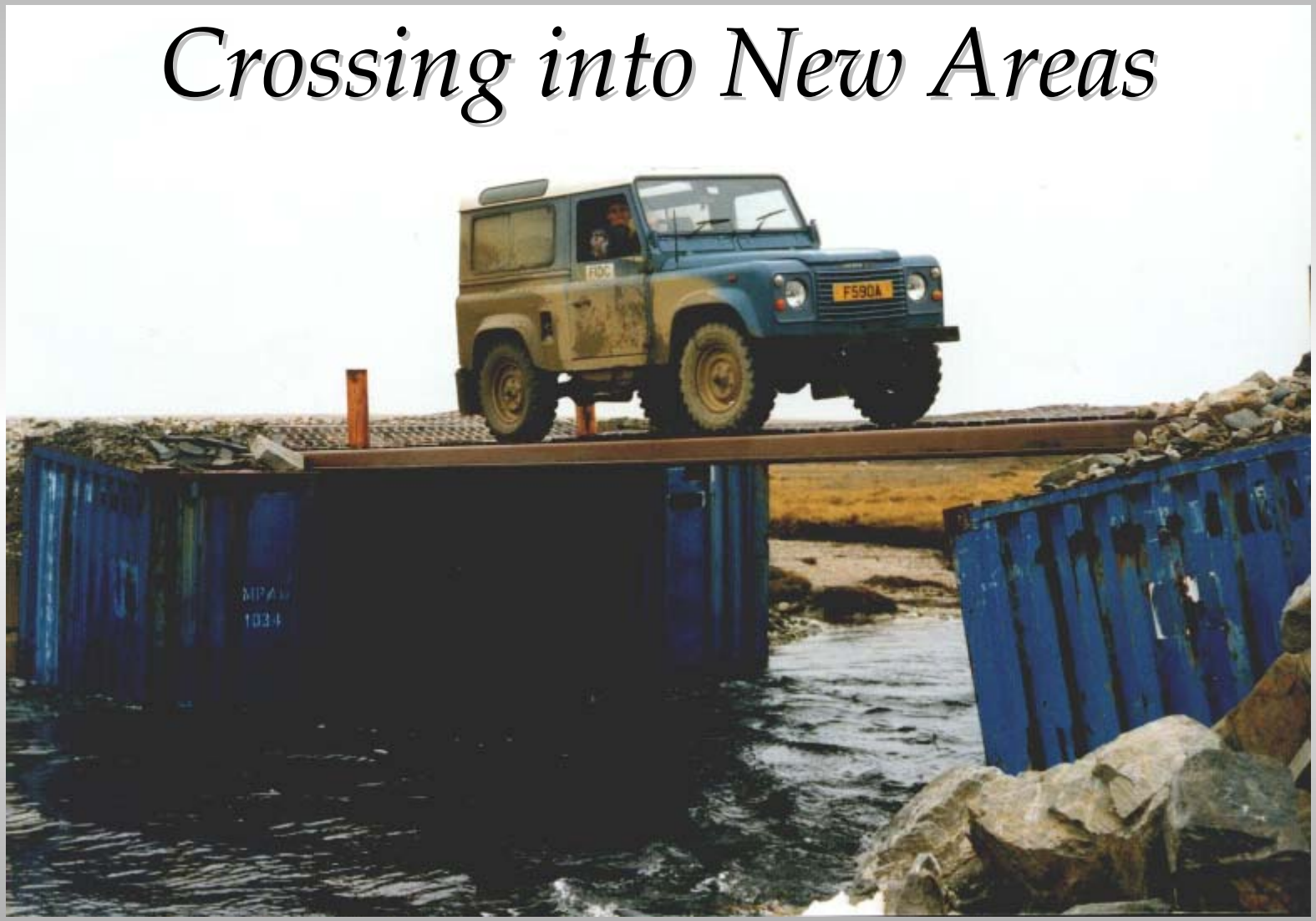
Distributed Storage Projects

- Port Howard (12 kW hydro rebuild)
  In progress
- Goose Green (20-50 kW Wind)
  Tender stage for phase 1 in progress
- North Arm (20-50 kW Wind)
- Fitzroy (20-50 kW Wind)

- Fox Bay (20-50 kW Wind)

Fox Bay has 24 hour power from diesel generators

Crossing into New Areas



Motor inverter drives

Industrial induction motor controllers

- High volume - Low cost commercial devices
- Proven reliability in an industrial environment
- Huge range available

Main features

- Provide controllable reactive power
- Power factor correction on grid side
- Soft start
- Variable speed motor operation
- Built in microprocessor control with extensive options

Regenerative power facility

Inverter drive turbine interface

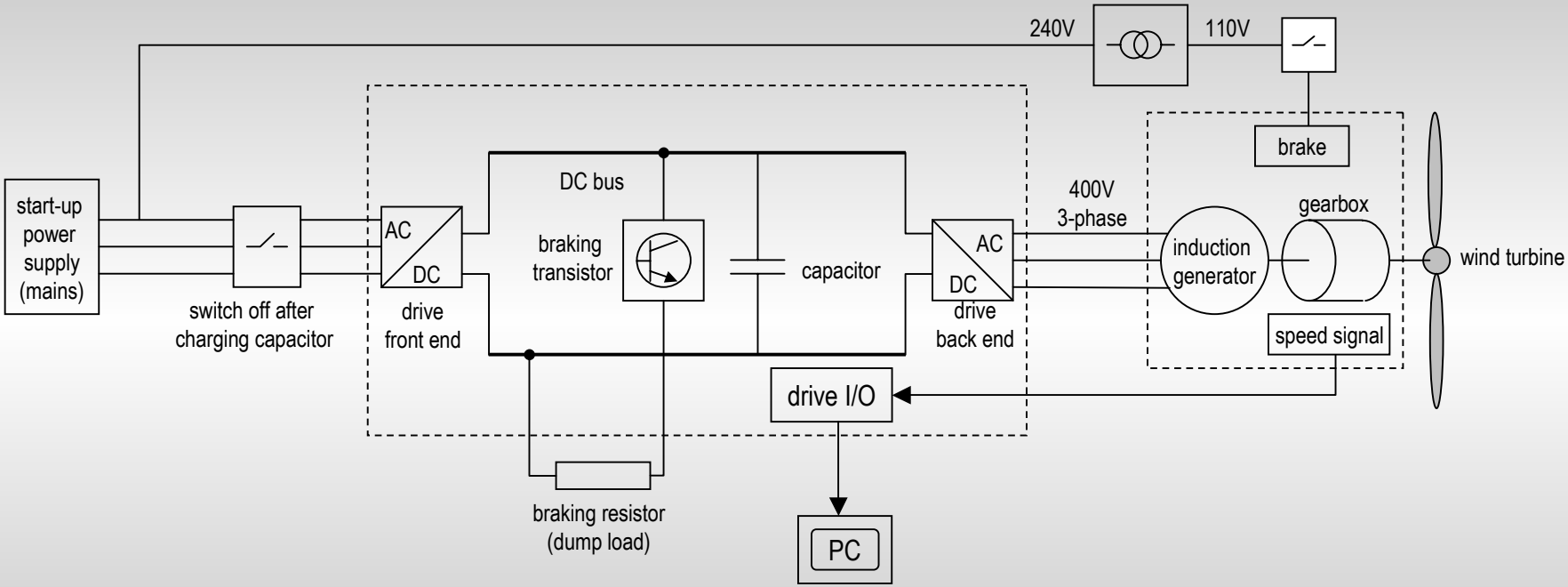
Alternative to a synchronous condenser

- Pretend the wind turbine is a motor
- Fit inverter drive large enough to handle regenerative power
- Program microprocessor and enable regenerative function
- GO! (Hopefully)

Advantages

- Reliable and inexpensive
- Efficient and flexible operation
- Turbine rpm independent of mains frequency

Experimental layout



Project supervisor – Dr Murray Thomson
Project researcher – Ruth Kemsley

Loughborough University

Possible developments

- Variable speed - fixed pitch operation

Change rotor rpm to maximise Cp over a range of wind speeds

- Battery storage on DC bus

To buffer against gusts

To black start wind turbine

- Single phase operation

Inverter drives can power 3 phase motors on single phase supplies.

Project development

Research

Loughborough University (CREST)

Beacon Energy (2 x 25kW Carter Wind Turbines)

Commercial involvement and assistance

Econnect Ltd.

Control Techniques Ltd.

Yaskawa (UK) Ltd

Falkland Islands Development Corporation

Falkland Islands Government Energy Policy

1. To reduce reliance upon imported fossil fuels for production of electricity throughout the Falkland Islands.

2. To reduce consumer operating costs through energy conservation and good energy house keeping.

3. To reduce production of carbon dioxide and other polluting emissions associated with the consumption of fossil fuels.

Falkland Islands Government Energy Policy

Broad Strategy

1.Investigate the viability of supplementing the Stanley electrical power system through wind power as a renewable energy source.

2. Provide encouragement for rural residents to conserve fuel oil through use of renewable energy technology.

3. Promote energy conservation measures in the public sector.

4. Ensure appropriate energy saving measures are considered for incorporation into all new building projects.

Falkland Islands Government Energy Policy

Broad Strategy

5. Promote energy conservation measures in the private sector through issue of advice and information.

6. Evaluate a grant assistance programme for insulation of domestic and commercial premises and the supply of low energy equipment.

7. Promote electrical safety tests by qualified personnel and provide encouragement and financial assistance with remedial work.

Supply, Installation & Service

All new Rural Energy Grant Scheme systems installed by Power Sense (Falkland Islands)

Local agent for renewable energy

Including Proven, Trace and Chloride

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