Microgrid Research in Australia

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CSIRO today: a snapshot

Australia’s national science agency
One of the largest and diverse in the world
Ranked in top 1% in 13 research fields
Internationally recognised staff
Award winning talent
Building national prosperity & wellbeing
Commonwealth Scientific and Industrial Research Organisation

From Wikipedia, the free encyclopedia
(Redirected from CSIRO)

The Commonwealth Scientific and Industrial Research Organisation (CSIRO) is the national government body for scientific research in Australia. It was founded in 1926 originally as the Advisory Council of Science and Industry.

Research highlights include the invention of atomic absorption spectroscopy, development of the first polymer banknote, invention of the insect repellent in Aerogard and the introduction of a series of biological controls into Australia, such as the introduction of Myxomatosis and Rabbit calicivirus which causes rabbit haemorrhagic disease for the control of rabbit populations. CSIRO's research into ICT technologies has resulted in advances such as the Panoptic Search Engine[1] (now known as Funnelback) and Annodex[2].

Recently, CSIRO has been actively defending its patent[3] for the use of wireless technologies which are a standard for many modern day laptops. A class action has been filed by US corporations Microsoft, Apple and Dell to renege on paying royalties on the wireless patent filed by CSIRO in 1996.

In October 2005 the journal Nature announced that CSIRO scientists had developed near-perfect rubber from resilin, the elastic protein which gives fleas their jumping ability and helps insects fly.[4] On 19
Where are we?
CSIRO Energy Centre
Microgrid at CSIRO Energy Centre, Newcastle

Wind turbine  Solar PV  Microturbine  Battery

Inverters

Offices

Energy Management System

Grid supply

Point of common coupling
Why are Microgrids important?

• Before 2015, *Pike Research* forecasts that over 3.1GW of new Microgrid capacity (1m homes) will come online worldwide, representing a total market value of $7.8 billion.

• Utilities beginning to embrace Microgrids rather than viewing them as a threat.

Source: Smart Grid News, Oct 29, 2009

Source – Harzing’s Publish or Perish
What are the expectations?

- We would like microgrids to:
  - Provide power security (military)
  - Provide reliability (manufacturing)
  - Incorporate high renewable penetration
  - Have neutral or good effect on network
  - Be “turnkey” and “plug and play”
  - Be cost effective
What are the challenges?

- Control – reliable power from intermittent sources
- Planning – the best mix of PV, wind, diesel, battery etc.
- Cost – is it really worth it?
- Protection – how to handle faults
Taming renewables - solutions

• Mix different types – solar, wind, gas cogen.
• Load prioritisation and shedding
• Storage – batteries, supercaps, flywheels
• Use smart techniques:
  • Forecasting
  • Weather data
  • Optimisation of loads & generation
Where are all the microgrids?

- Australia has a significant number for its population size – why?
Why does Australia like Microgrids?

<table>
<thead>
<tr>
<th>Location</th>
<th>Purpose</th>
<th>Renewables</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSIRO, Newcastle, New South Wales</td>
<td>Experimental</td>
<td>110kW PV</td>
</tr>
<tr>
<td>Kings Canyon, Northern Territory</td>
<td>Tourism</td>
<td>225kW PV</td>
</tr>
<tr>
<td>Coral Bay, Western Australia</td>
<td>Isolated</td>
<td>825kW wind</td>
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<tr>
<td>Bremer Bay, Western Australia</td>
<td>Isolated</td>
<td>660kW wind</td>
</tr>
<tr>
<td>Denham, Western Australia</td>
<td>Isolated</td>
<td>920kW wind</td>
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<tr>
<td>Esperence, Western Australia</td>
<td>Isolated</td>
<td>3600kW wind</td>
</tr>
<tr>
<td>Hopetoun, Western Australia</td>
<td>Isolated</td>
<td>1200kW wind</td>
</tr>
<tr>
<td>King Island, Tasmania</td>
<td>Isolated</td>
<td>110kW solar</td>
</tr>
<tr>
<td>Rottnest Island, Western Australia</td>
<td>Tourism</td>
<td>600kW wind</td>
</tr>
</tbody>
</table>
“It wasn't that long ago that microgrids were commonly thought of in the utility industry as negatives: They were supposedly unsafe. And worse, they were competition. But it looks like more utilities and other industry players see them as critical building blocks that will help ensure the efficiency and reliability of the Smart Grid.”

- Are We Taking Microgrids Seriously — Finally?
www.smartgridnews.com Feb 18, 2010
How can microgrids help the network?
Some scenarios:

1. **Microgrid operated independent of utility:**
   - Appears as regular load, but more intermittent because of renewable energy sources
   - Stability issues worse

2. **Microgrid controlled by utility**
   - Signal from utility to curtail load
   - Renewable problem remains, but its Microgrid operators problem

3. **A mixture of both**
   - Time of use tariffs
   - Depends on good local control of Microgrid
   - Solution is a compromise between cost and technical limits
What is our path and target?

- **Goal #1:** Microgrids will have high renewable penetration
  - Better design through the use of AI for planning
  - Improved operation (load shedding, battery dispatch) using AI
  - Incorporate weather forecasting using AI
  - New options for protection systems

- **Goal #2:** Microgrids will be part of the Smart Grid
  - Simulation of effects of multiple microgrids on distribution system
  - Apply game theory to understand how microgrids might “play” the tariff structure, within their own constraints
Current work on Microgrids – Planning Tool

- **Issues:**
  - What generation?
  - Where?
  - Batteries?
  - Use of heat?

- **Optimisation:**
  - Installation cost
  - Maintenance cost
  - CO$_2$ emission
  - Electrical losses
Current work on Microgrids – Control

• Electrical energy is difficult (or expensive) to store
  • supply must match consumption

• Conventional grid:
  • Amount of generation is changed to suit load
  • Many sources and consumers – fine-grained

• Microgrid:
  • Time-varying nature of renewables
  • Load can be adapted to suit generation
  • Few sources and consumers – coarse-grained
  • Use frequency and voltage, or rely on high-speed data communications?
  • Prediction of generation (weather data)
  • Prediction of load (customers habits)
  • Amount and type of storage
Current work on Microgrids – Control

- How do inverters interact?
- Response to sag and flicker?
Current work on Microgrids – Protection

• Conventional grid:
  • Short circuit leads to large currents flowing
  • Detect this and open switches to isolate

• Microgrid:
  • Larger fault currents when grid connected
  • Smaller fault currents when islanded
  • Difference may not be detected – more data needed
  • Frequency changes, rate of change, harmonics
  • Characterise normal operation, use pattern recognition / AI
  • How to detect with minimum sensors
Current work on Microgrids – Protection

- What types of electrical fault occur in a Microgrid?
- Are they the same as those in a grid – connected site?
- How can faults be distinguished from benign phenomena?
Future Microgrid Challenges

• How to extend Microgrid research into the distribution (utility) grid:
  • Microgrids as a low cost, low risk entry point into the “smart grid”
  • Our experimental facilities as testing ground for the “smart grid”

• Challenges:
  • Improve control of electrical properties of the grid
  • Incorporate more renewable energy
CSIRO microgrid laboratory
CSIRO microgrid laboratory