Integrating and optimizing renewables in microgrids

Lessons learned from Australia

Prepared for Microgrid 2.0
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29 Oct. 2018
Agenda for today

- Brief background
- Case studies
  - Esperance
  - Coral Bay
  - Exmouth
  - DeGrussa Mine
- Modelling approaches
- Lessons learned

Photo: Courtesy TransGrid
Smart & Distributed Energy systems experience

Across both urban and remote settings:

- Hybrid systems featuring >95% energy from renewable generation
- Mines
- Islands
- Critical infrastructure
- Remote communities
- Airports & Marine ports
- Real estate
Australian Antarctic Base at Mawson – two, Enercon E33 low temperature purpose designed turbines installed in 2003 - $U_{\text{max}}$ around 250km/h, Temp $<$ -30
8th November 2017, turbine failure

When you push the boundaries – in this case wind at their engineering limits – sometimes things break and there are obviously serious issues around such. Should this stop us trying though?
Australia – a few example projects

Assessment of project for funding support – use of existing spinning reserve battery for solar balancing

Due diligence & lenders engineer for solar + battery + diesel micro-grid

Delivery project management support for 5MW/3.4MWh battery for solar smoothing

Project management, control logic analysis, grid studies, procurement and development assistance for 55MW_{AC} solar + 20MW/80MWh battery project

Concept design and delivery owners engineer for grid connected C&I solar + battery + hydrogen electrolysis + gas/H2 engine micro-grid

Concept design and financial assessment for behind the meter batteries, coal mining operations
Small, islanded microgrids

Connection to remote mine loads and/or grid

Mine processing

Renewables

Main power station

Energy storage unit

Electrical connection & control

Renewables
Exmouth power station

- Dual gas/diesel system of 8MW capacity commissioned in 2006
- “Mini wind farm” to use small tilt down wind turbines in a severe cyclone environment
- Photo: one of the 10kW machines (there are 3)
Coral Bay

- 7x 320kW low load diesels
- 3x 225kW wind turbines
- 1 x 500 kW flywheel energy storage
- Commissioned in 2007
Coral Bay

The low load diesels are specifically designed to operate down to 10% loading for extended periods.

The flywheel is for spinning reserve and to control ramp rates from the induction generator based wind turbines.

Average wind penetration is around 45% but it can run for extended periods for higher than 95%.
DeGrussa Mine

• Large operational energy demands, using a 19MW diesel-fired power station to provide electricity to the gold and copper mine

• They wanted to supplement the power station with 10.6MW of photovoltaics (PV) and a 4MW lithium-ion battery system in order to reduce their overall energy generation costs
System Modelling Approach

Packages used by WorleyParsons in Australia

- PSS/E, PTI Technologies Inc.
- PSS/ADEPT, PTI Technologies Inc.
- ETAP PowerStation, Operation Technology Inc.
- ERACS, ERA Technology Ltd
- Matlab
- Mathematica, WOLFRAM
- CDEGS “Current Distribution Interference Grounding and Soil”
- EMTP “Electromagnetic Transient Program”

- Bespoke software written if required for specific project issues
Specific DER & Microgrid Modelling:

**BANKABLE DER & MICROGRID PROJECTS**

- Integrated End-to-End Investment and Technical Planning Platform
- Economic and Financial Optimization + Power Flow Analysis
- XENDEE Score: Getting DER Projects Down to a Single ‘FICO’ Number
Why Economic Optimization and not just Simulation?

With permission of Berkeley Lab
**XENDEE Process**

**For your energy project**
- Microgrid
- Battery Energy Storage
- Electric Vehicles
- Alternative Energy System

**Your priorities**
- Cost Savings
- Emissions Reduction
- Resilience & Reliability
- Safety & Security

**XENDEE PLATFORM**

**Your data**
- Location
- Facility type and use
- Energy use mix/cost
- Load profile

**Platform data**
- Energy pricing
- Solar and wind data
- Vendor data
- Geospatial analysis

**Technical & Financial Optimization**

**Fast, reliable results**
- Financial pro forma
- Customized system design
- Technical report
- Optimized operations

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**For your energy project**

**Your priorities**

**XENDEE PLATFORM**

**Your data**

**Platform data**

**Technical & Financial Optimization**

**Fast, reliable results**

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For your energy project
XENDEE PLATFORM
Fast, reliable results
www.worleyparsons.com   |   www.advisian.com
Your data ...
Platform data...
Technical & Financial Optimization
Fast, reliable results
Financial pro forma   |   Customized system design   |   Technical report   |   Optimized operations
Step 1: Set your priorities

- Cost savings
- Emissions reduction
- Resilience & reliability
- Safety & security

XENDEE platform
Step 2: Input site-specific data

- Location
- Facility type & use
- Energy use mix/cost
- Load profile

XENDEE platform
Step 3: Apply platform data

- Location
- Facility & use
- Energy use mix/cost
- Load profile
- Energy pricing
- Solar & wind data
- Vendor data
- Geospatial analysis

XENDEE platform
Step 4: Run technical & financial optimization

- Location
- Facility & use
- Energy use mix/cost
- Load profile

XENDEE platform

- Energy pricing
- Solar & wind data
- Vendor data
- Geospatial analysis
Step 5: Fast, reliable results

- XENDEE platform
- Least cost, best fit solutions
- Validated, auditable results

- Financial pro forma
- Customized system design
- Technical report
- Optimized operations
8760 Power flow

Integrated deep-circuit power flow analysis:
- Automatic one-line generation
- Quasi-static time-series simulation
- Distribution system planning
- Google maps integrated for GIS views

Automatic Report Generation

Power Flow Reporting on One-Line Diagram
Sequence of operations

Most Optimal Sequence of Operation Logic Output
(September outage day)

Load Shape (September day)
Summary report

Summary: Annualized Energy Costs ($000s)

Annualized Energy Costs

<table>
<thead>
<tr>
<th>Reference</th>
<th>Optimized</th>
<th>Annualized Investment Costs</th>
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<td>$1,517</td>
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Summary: Yearly Investments and Operational Costs

Yearly Investments and Operational Costs
Lessons learned

- Optimize for the use case (*not* redundancy everywhere)
- Renewables + Storage are competitive now
- Hybrid systems offer the greatest flexibility and cost competitiveness
- Specialized software for system optimization can save up to 90% of soft costs
- Consider the full range of technology options (remain technology agnostic)
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