Distributed Generation: Regulatory & Institutional Barriers

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Distributed generation in a restructured electricity industry

- Primary energy markets
  - Wholesale Market region
  - Transmission network
  - Interchange to other wholesale market regions

- Retail Market 1: distribution network
- Retail Market 2: distribution network
- Retail Market 3: distribution network

- Location-dependent risks to flow of end-use energy services

- Large generators
- Most consumers
- Embedded generators

- Small consumers, distributed generators & storage should be supported by energy service advisers

- Wholesale & retail designs should be compatible, with spot & derivative markets that model flow constraints
Energy service delivery in the stationary energy sector with distributed resources

Primary energy forms e.g.: coal, gas, nuclear, renewable

The electricity supply industry
- generation
- transmission
- distribution

The natural gas supply industry
- treatment
- transmission
- distribution

End-user options, eg: efficiency, response, CHP, solar
Embedded generation & reversible storage

Energy service companies (ESCOs)

Energy losses & external impacts
Energy service companies (ESCOs)

- Promote distributed resource (DR) options, such as embedded generation, flexible (price-responsive) demand, increased end-use efficiency
- More used to working with commercial & industrial than residential end-users (eg energy contracting)
- Should assess life-cycle cost-benefits, including availability, quality & external impacts
- Need efficient *retail spot & derivative markets* for energy & ancillary services including externalities:
  - Without efficient & consistent retail contracts, rebound effects will negate energy efficiency enhancements
Some distributed resource options

- Gas-based embedded generation options:
  - Reciprocating engines, small gas turbines, fuel cells
  - Waste heat recovery (heating, cooling, electricity)

- Renewable energy embedded generation options
  - PV, wind, solar thermal (heat & electricity)

- Intermediate & end-use energy storage

- End-uses options:
  - Flexibility (price or direct load control)
  - Enhanced end-use efficiency & frugality

- Metering, communications & control
Availability & quality of supply

- Quality of supply attributes (QOS):
  - Voltage, frequency, waveform purity
  - Supply availability

- Perfect availability & quality not achievable:
  - Supply availability & quality can vary widely in distribution networks
  - Customer equipment can also affect quality

- Risks to availability & quality of supply threaten the flow of end-use energy services:
  - Directly or indirectly through equipment malfunction
  - Hard to define legal obligations (mainly on distributors) for availability & quality at end-user connection points
## Contributions to unavailability of supply for small end-users (USA data, AEMC, 2006)

<table>
<thead>
<tr>
<th>Contributor</th>
<th>Average unavailability per customer year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(minutes)</td>
</tr>
<tr>
<td>Generation/transmission</td>
<td>0.5</td>
</tr>
<tr>
<td>132 kV</td>
<td>2.3</td>
</tr>
<tr>
<td>66kV and 33kV</td>
<td>8.0</td>
</tr>
<tr>
<td><strong>11kV and 6.6kV</strong></td>
<td><strong>58.8</strong></td>
</tr>
<tr>
<td>Low voltage</td>
<td>11.5</td>
</tr>
<tr>
<td>Arranged shutdowns</td>
<td>15.7</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>96.8 minutes</strong></td>
</tr>
</tbody>
</table>

Outages of overhead radial distribution feeders are the main cause of unavailable supply.
### NEM DNSP reliability targets

**SAIDI** = system ave. outage duration in min/yr

**SAIFI** = system ave. no. of outages per year

**CAIDI** = SAIDI/SAIFI = customer ave. outage duration in min/yr

(AEMC, 2006)

<table>
<thead>
<tr>
<th>Region</th>
<th>DNSP</th>
<th>Feeder</th>
<th>SAIDI</th>
<th>SAIFI</th>
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<tbody>
<tr>
<td>Queensland</td>
<td>Energex</td>
<td>CBD</td>
<td>20</td>
<td>0.33</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Urban</td>
<td>162</td>
<td>1.78</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Short Rural</td>
<td>272</td>
<td>2.84</td>
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<tr>
<td></td>
<td>Ergon Energy</td>
<td>Urban</td>
<td>220</td>
<td>2.75</td>
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<tr>
<td></td>
<td></td>
<td>Short Rural</td>
<td>610</td>
<td>5.70</td>
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<tr>
<td></td>
<td></td>
<td>Long Rural</td>
<td>1,180</td>
<td>9.00</td>
</tr>
<tr>
<td>New South Wales</td>
<td>Integral Energy</td>
<td>Total</td>
<td>374</td>
<td>2.91</td>
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<tr>
<td></td>
<td>Energy Australia</td>
<td>Total</td>
<td>102</td>
<td>1.20</td>
</tr>
<tr>
<td></td>
<td>Country Energy</td>
<td>Total</td>
<td>403</td>
<td>3.56</td>
</tr>
<tr>
<td></td>
<td>Australian Inland</td>
<td>Total</td>
<td>303</td>
<td>1.70</td>
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<tr>
<td>South Australia</td>
<td>ETSA</td>
<td>Urban</td>
<td>90</td>
<td>1.10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rural</td>
<td>290</td>
<td>2.65</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Remote</td>
<td>200</td>
<td>1.20</td>
</tr>
<tr>
<td>Victoria</td>
<td>Citipower</td>
<td>CBD</td>
<td>21.4</td>
<td>0.25</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Urban</td>
<td>44.9</td>
<td>0.80</td>
</tr>
<tr>
<td></td>
<td>TXU</td>
<td>Urban</td>
<td>116.0</td>
<td>1.78</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Short Rural</td>
<td>216.0</td>
<td>2.75</td>
</tr>
<tr>
<td></td>
<td>Powercor</td>
<td>Total</td>
<td>212.0</td>
<td>2.28</td>
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<tr>
<td></td>
<td>AGL</td>
<td>Urban</td>
<td>79.0</td>
<td>1.27</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Short Rural</td>
<td>127.0</td>
<td>2.25</td>
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<td></td>
<td>United Energy</td>
<td>Urban</td>
<td>79.0</td>
<td>1.17</td>
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<td></td>
<td></td>
<td>Short Rural</td>
<td>128.0</td>
<td>2.24</td>
</tr>
<tr>
<td>ACT</td>
<td>ActewAGL</td>
<td>All</td>
<td>91</td>
<td>1.2</td>
</tr>
</tbody>
</table>
Network connection: NSP gatekeeper (NER Ch5)

- **Code participant**
  - Preliminary enquiry
  - Try another NSP
  - Prepare application
    - Apply & pay fee
  - Provide additional information
  - Finalise connection agreement

- **Network service provider**
  - Assess network suitability
  - Prepare:
    - Preliminary program
    - Performance specification
    - Technical data lists
    - Application fee estimate
    - Commercial requirements
  - Advise applicant
  - Investigate application:
    - Technical & economic studies
    - Liase with other NSPs
    - Seek additional information
  - Make offer to connect

*Connection does not guarantee market access under all conditions*
Connection requirements for generators in National Electricity Rules

- Reactive power & voltage control capability
- Quality of electricity injected into network
- Protection requirements
- Remote control arrangements
- Excitation system requirements
- Loading rates
- Ride-through to avoid cascading outages:
  - Loss of largest generator; 175ms network fault
- *Issues concerning availability obligations*
Australian electricity restructuring to date

- Has focussed on wholesale market design, network services & ancillary services
- Has not focussed on retail market design or end-user concerns about quality of supply:
  - This has hindered the development of distributed gen’n
- However a number of policies now favour DG:
  - Distribution regulation & pricing review
  - Roll-out of interval metering in NSW & Victoria
  - Policies on end-use efficiency (NFEE & jurisdictions)
  - Renewable energy targets & gas industry restructuring
  - Evolving climate change policies
<table>
<thead>
<tr>
<th>Jurisdiction</th>
<th>Long-term (2050) economy-wide targets</th>
<th>Intermediate economy-wide targets</th>
<th>Renewable or low emission targets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commonwealth Government</td>
<td>No policy. (To be announced in 2008.)</td>
<td>Annual caps for period up to 2020 for an emission trading scheme to be announced in 2010.</td>
<td>2% extra renewable energy target by 2010 (legislated)</td>
</tr>
<tr>
<td>New South Wales</td>
<td>60% reduction on 2000 levels</td>
<td>Return to 2000 levels by 2025</td>
<td>10% renewable energy target by 2010 and 15% by 2020</td>
</tr>
<tr>
<td>Victoria</td>
<td>60% reduction on 2000 levels</td>
<td></td>
<td>10% renewable energy target by 2016 (legislated)</td>
</tr>
<tr>
<td>Queensland</td>
<td>60% reduction on 2000 levels</td>
<td></td>
<td>18% gas generation by 2020 and 10% low emission target by 2020</td>
</tr>
<tr>
<td>South Australia</td>
<td>60% reduction on 1990 levels (legislated)</td>
<td></td>
<td>20% renewable energy target by 2014 (legislated)</td>
</tr>
<tr>
<td>Western Australia</td>
<td>60% reduction on 2000 levels</td>
<td></td>
<td>15% renewable energy target by 2020 and 20% by 2025</td>
</tr>
<tr>
<td>Tasmania</td>
<td>60% reduction on 2000 levels</td>
<td>Return to 2000 levels by 2025</td>
<td>Implement a renewable energy target in line with NSW.</td>
</tr>
</tbody>
</table>
Present electricity industry structure in SE Australia

**Generation Sector:**
- Large generators
  - Gen 1
  - Gen 2
  - Gen 3
  - Gen X

**Transmission Sector:**
- NSW
- Victoria
- South Aust.
- Queensland
- & possibly Tasmania

**Financial instrument & REC (emission) trading**
- Intentions offers & payments

**Multi-region National Electricity Market (NEM)**
- Intentions bids & payments

**Retail sector**
- Retailer 1
- Retailer 2
- Retailer Z

**Distribution sector**
- Distributor 1
- Distributor 2
- Distributor Y

**End-use sector**
- Contestable end-users
- Franchise End-users
- Embedded generators
- End-use Equipment & Distributed resources

**Retail Markets**
- Network access

**Distribution sector**
- Network access

**Electricity**
- Distributed generation: regulatory &
Enhanced NEM structure with active end-user participation

ESCOS: the missing players in the restructured electricity industry

ESCO's

Services

cash flow

Intentions, offers & payments

Intentions, bids & payments

Energy flow

Intentions, bids & payments

Energy flow

Intentions, offers & payments

Energy flow

Kinetic energy

Distributed generation: regulatory & institutional barriers
Managing future uncertainty in the NEM

Unreachable or unacceptable futures

Present state

Growing uncertainty

Distributed generation

Emergency control

Possible futures managed by decentralised decisions taken by NEM participants

Time

Could distributed resources play a greater role in managing future uncertainty?

Growing uncertainty

Possible futures managed by centralised decisions

5 min
Cash flow in SE Australia electricity industry
(Spalding, 2006)

Should we allocate more of these funds to distributed resources?

End users

Retailers

NEM generators

NEMMCO Spot Mkt

NEMMCO Ancillary services

Derivative markets

DNSPs

TNSPs

Embedded generators

$20B

$6B

$80M

$5.8B

$200M

$12B

$2B

$80M

$20B

$6B

$5.8B

$200M

$12B

$2B

$80M

$20B

$6B

$5.8B

$200M

$12B

$2B

$80M

$20B

$6B

$5.8B

$200M

$12B

$2B

$80M

$20B

$6B

$5.8B

$200M

$12B

$2B

$80M

$20B

$6B

$5.8B

$200M

$12B

$2B

$80M

$20B

$6B

$5.8B

$200M

$12B

$2B

$80M

$20B

$6B

$5.8B

$200M

$12B

$2B

$80M

$20B

$6B

$5.8B

$200M

$12B

$2B
Residential electricity bill cost components
(IPART, DNSP Review, 2003)
NSW summer & winter peak demand
(Owen Inquiry Report App 2, 2007)
(Owen Inquiry Report App 2, 2007)
Load curves for 2006 summer & winter peak days
(Owen Inquiry Report App 2, 2007)

Summer peak more onerous for supply system
(higher temperatures, longer duration)
NSW Demand Management Code
(to be replaced & extended to other states by COAG policy)

- DNSPS required to develop DR expertise
- DR options to be developed in-house & externally
- Market to be tested for options when reasonable
- Market to be informed well in advance of constraint
- Network & DR options to use the same database
- Clear & transparent option comparison
- Process assessed by IPART as DNSP regulator:
  - IPART allows full cost recovery for cost-effective options as well as additional incentives for DR activities
Distributor investment considering distributed resources
(NSW Demand Management Code of Practice, 2004)

1. Inform the market via annual plan

2. Specify constraints, test the market & evaluate options

- **DR Offer(s) cheaper:**
  - Negotiate contract(s) with DR providers
  - (revert to network option if negotiation fails)

- **Network option cheaper:**
  - Proceed with preferred network option

3. Report outcomes & update plans
Example: Transmission Network Mid North Coast (Transgrid, 2007)

Proposed Herons Creek PS 3x50MW CT-diesel fuel: *strong community opposition*

Emerging network constraint Beresfield-Taree (2008)
Stroud to Port Macquarie load history
(Transgrid, 2006)
Taree to Port Macquarie peak load shapes (Transgrid, 2006)

Summer peak more onerous for network (higher temperatures, longer duration)

Herons Creek 150MW?
Taree to Port Macquarie load duration curves (Transgrid, 2006)

Summer peak more onerous for network (higher temperatures, longer duration) (OCGT rating & efficiency lower in summer)
### Load growth & load reduction effectiveness
(Transgrid, 2006)

<table>
<thead>
<tr>
<th>Area</th>
<th>Relevant Network Outage(s)</th>
<th>Forecast Summer Load Growth (MW p.a.)</th>
<th>Forecast Winter Load Growth (MW p.a.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coffs Harbour to Stroud Area</td>
<td>(Future) Armidale – Coffs Harbour 330 kV line</td>
<td>21</td>
<td>13</td>
</tr>
<tr>
<td>Stroud to Port Macquarie Area</td>
<td>Kempsey – Port Macquarie 132 kV line</td>
<td>14</td>
<td>8</td>
</tr>
<tr>
<td>Stroud to Taree Area</td>
<td>Beresfield – Stroud 132 kV line</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Tomago – Taree 132 kV line</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taree (66 kV)</td>
<td>Taree 132/66 kV Transformer</td>
<td>4.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Kempsey (33 kV)</td>
<td>Kempsey 132/33 kV Transformer</td>
<td>2</td>
<td>1.3</td>
</tr>
</tbody>
</table>

**Heron Creek PS: location sound but large compared to load growth**

<table>
<thead>
<tr>
<th>Line Outage</th>
<th>Location of Load Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coffs Harbour</td>
</tr>
<tr>
<td>Armidale – Coffs Harbour 330 kV line</td>
<td>0.2</td>
</tr>
<tr>
<td>Kempsey – Port Macquarie 132 kV line</td>
<td>No Effect</td>
</tr>
<tr>
<td>Beresfield – Stroud 132 kV line</td>
<td>Negligible</td>
</tr>
</tbody>
</table>
Transgrid near-term augmentation options for Stroud – Port Macquarie
(Transgrid, 2007)

<table>
<thead>
<tr>
<th>Option</th>
<th>Description</th>
<th>Scenario 1</th>
<th></th>
<th>Scenario 2</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>PV of Costs ($M)</td>
<td>Rank</td>
<td>PV of Costs ($M)</td>
<td>Rank</td>
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<tr>
<td>Option 1</td>
<td>Kempsey – Port Macquarie Line</td>
<td>13.5</td>
<td>1</td>
<td>13.5</td>
<td>1</td>
</tr>
<tr>
<td>Option 2</td>
<td>Kempsey – Herons Creek Single Circuit Line</td>
<td>19.3</td>
<td>2</td>
<td>22.9</td>
<td>3</td>
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<tr>
<td>Option 3</td>
<td>Kempsey – Herons Creek Double Circuit Line</td>
<td>23.5</td>
<td>3</td>
<td>22.0</td>
<td>2</td>
</tr>
</tbody>
</table>

- **Option 1 presently out for tender, to be commissioned by mid 2010**
- **Further augmentation likely south of Herons Creek at a later date**
Example: Sydney region DM project

- **Participants:**
  - Transgrid, EnergyAustralia (distributor), NSW Dpt of Industry, Planning & Natural Resources (DIPNR)

- **Objectives:**
  - Identify & develop cost-effective DR options to defer or avoid network augmentation in inner Sydney region

- **Options considered (12/03 to date):**
  - Stand-by generation, interruptible load, power factor correction, innovative HVAC, building design (Basix)
NSW transmission network, Sydney region (M Park, 2005)
EnergyAustralia vision for network pricing (Colebourn, 2006)
EnergyAustralia distributor meter & network tariff strategy (H Colebourn, 2005)

- Only half-hour meters installed since July 2004
- Replacement half-hour meters for most of 25,000 40-160 MWH end-users installed by June 2005
- Replacement half-hour meters for 110,000 15-40MWH end-users by June 2010
- 3-rate TOU network tariff from March 2005
- Seasonal TOU network tariff from July 2005
- Tests of communication systems to support non-predicted pricing & interruptible loads
Spot & derivative access contract based on EA trial of residential dynamic peak pricing (Colebourn, 2006)

CFD profile based on ave WWD demand

End-user pays spot price for energy above contract

End-user is paid spot price for energy below contract

Average temperature

CFD profile based on ave WWD demand

End-user pays spot price for energy above contract

End-user is paid spot price for energy below contract
Possible residential NSP forward contracts

- Forward demand profile to meet basic household needs for normal weather conditions:
  - May include a location-influenced allowance for air-conditioning
  - May be a function of household size
  - May include energy as well as network pricing

- Forward price profile determined by area-specific network LRMC estimate for cost of supply:
  - Considering economically efficient investment

- Forward term to be 3-5 years with annual update

- To be determined by regulator & offered by DNSP:
  - As default derivative aggregator if energy pricing included
Climate change implications

- Aust. already affected by climate change impacts
- Need rapid & deep reductions in emissions:
  1. End-use options: frugality, enhanced efficiency, CHP, fuel-switching, renewable energy at point of end-use
  2. Currently available low-emission supply-side options:
      - Gas CCGT, large-scale renewable energy generation
  3. Convert coal-fired power stations to gas CCGT (as at Tallawarra) with industrial use of waste heat
  4. Convert retailers to ESCOs
- Emission trading too slow – better used for fine-tuning once major reductions achieved
Conclusions on valuing DG contribution

- Three important issues in valuing DG:
  - Time-varying value of energy should reflect flow constraints
  - Quality of supply, particularly voltage & frequency
  - Obligation to serve

- DG role can be facilitated by coordinated technical & market mechanisms
  - Non-predetermined prices for energy & ancillary services:
    - Value DG improvements to availability & quality of supply
    - Penalise disturbances to availability & quality of supply
  - Communication & interval metering with QOS measurement
  - ESCOs would assist end-users to respond efficiently
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Many of our publications are available at:
www.ceem.unsw.edu.au