

ONE-PAGE ELECTRICITY MARKET DESIGN SUMMARY

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Entities responsible for electricity market functions

Where the jurisdiction procures capacity separately from energy:

1. Capacity is procured through an auction.
2. The price is set by a central authority rather than an open market mechanism.
3. Retailers/large consumers are obliged to hold contracts or capacity certificates.
4. Retailers/consumers can engage directly with producers to meet capacity obligations.

Risk management mechanisms:

1. Standardised contract forms for bilateral contracting
2. Exchange traded futures
3. Financial transmission rights, settlement residue auctions and the like

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Centrally managed, financially &/or physically firm spot energy markets.

Non-energy services. Also known as as System Support Services or Essential System Services

Retail market characteristics:

1. Whether the market allows at some or all consumers a choice of electricity retailer.
2. Minimum demand required to qualify as a contestable customer.
3. Whether the market allows consumers/retailers a choice of meter equipment and/or data provider.
4. Approach to reconciling meter data and allocating unmetered consumption.

Scheduling and dispatch characteristics:

1. Gross pool: participants offer all generation capability, all generation quantities determined in central dispatch. Net pool: participants nominate self-scheduled quantities, deviation quantities determined in central dispatch.
2. Time granularity for which dispatched quantities are calculated
3. Extent to which facility commitment is managed by the participant vs instructed by the market operator
4. Extent to which market scheduling algorithms account for network and security constraints
5. How the market algorithms treat network losses
6. Dispatch compliance requirements on intermittent generation
7. Extent to which battery storage devices can provide market services

| ELECTRICITY MARKET SUMMARY - NEW ZEALAND | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|--|--|--|--------------------|--|----------------------|-----------------------|----------------------|-----------------------|---|------------|------------------------|------------|------------------|----------------------------|----------|---|------------------|------------|----------|------------|----------|---|---|---|-------------|---------------------|---------------------|--|--|--------------------|---|----------------------------|--------------|---------------------|---------|-----------------------|--|------------------|-----------------|---|--|
| Governance | Dispatch | Settlement | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <table border="1"> <tr><td>Policy</td><td>Ministry of Business, Innovation & Employment</td></tr> <tr><td>Regulation</td><td>Electricity Authority (market), Commerce Commission (monopolies)</td></tr> <tr><td>Market design lead</td><td>Electricity Authority</td></tr> <tr><td>Rule making</td><td>Electricity Authority</td></tr> <tr><td>Scheduling & dispatch</td><td>Transpower</td></tr> <tr><td>Power system operation</td><td>Transpower</td></tr> <tr><td>Market operation</td><td>NZX EMT, (FTR), ASX (ETFs)</td></tr> <tr><td>Metering</td><td>Vector AMS, IntelHub, SmartCo, + 9 other metering equipment providers</td></tr> <tr><td>Network planning</td><td>Transpower</td></tr> <tr><td>TX owner</td><td>Transpower</td></tr> <tr><td>DX owner</td><td>Vector PowerCo, Chon, Wellington Electricity, +25 other regional distributors</td></tr> </table> | Policy | Ministry of Business, Innovation & Employment | Regulation | Electricity Authority (market), Commerce Commission (monopolies) | Market design lead | Electricity Authority | Rule making | Electricity Authority | Scheduling & dispatch | Transpower | Power system operation | Transpower | Market operation | NZX EMT, (FTR), ASX (ETFs) | Metering | Vector AMS, IntelHub, SmartCo, + 9 other metering equipment providers | Network planning | Transpower | TX owner | Transpower | DX owner | Vector PowerCo, Chon, Wellington Electricity, +25 other regional distributors | <p>Gross pool ①</p> <p>Net pool ②</p> <p>Dispatch interval ③</p> <p>5 min ④</p> <p>Inter-connects</p> <p>None ⑤</p> <p>Local pricing ⑥</p> <p>Congestion in price ⑦</p> | <table border="1"> <tr><td>Final prices</td><td>①</td></tr> <tr><td>Trading interval</td><td>②</td></tr> <tr><td>Energy price floor</td><td>\$0/MWh</td></tr> <tr><td>Energy price ceiling</td><td>\$20,000/MWh</td></tr> <tr><td>Reserve price floor</td><td>\$0/MWh</td></tr> <tr><td>Reserve price ceiling</td><td>None</td></tr> <tr><td>Scarcity pricing</td><td>③</td></tr> <tr><td>Intervention pricing</td><td>④</td></tr> </table> | | Final prices | ① | Trading interval | ② | Energy price floor | \$0/MWh | Energy price ceiling | \$20,000/MWh | Reserve price floor | \$0/MWh | Reserve price ceiling | None | Scarcity pricing | ③ | Intervention pricing | ④ |
| Policy | Ministry of Business, Innovation & Employment | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Regulation | Electricity Authority (market), Commerce Commission (monopolies) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Market design lead | Electricity Authority | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Rule making | Electricity Authority | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Scheduling & dispatch | Transpower | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Power system operation | Transpower | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Market operation | NZX EMT, (FTR), ASX (ETFs) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Metering | Vector AMS, IntelHub, SmartCo, + 9 other metering equipment providers | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Network planning | Transpower | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| TX owner | Transpower | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| DX owner | Vector PowerCo, Chon, Wellington Electricity, +25 other regional distributors | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Final prices | ① | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Trading interval | ② | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Energy price floor | \$0/MWh | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Energy price ceiling | \$20,000/MWh | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Reserve price floor | \$0/MWh | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Reserve price ceiling | None | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Scarcity pricing | ③ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Intervention pricing | ④ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Capacity | Contracts | Ancillary services | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <table border="1"> <tr><td>Auction</td><td>①</td></tr> <tr><td>Administered price</td><td>②</td></tr> <tr><td>Retailer obligations</td><td>③</td></tr> <tr><td>Bilateral agreements</td><td>④</td></tr> </table> | Auction | ① | Administered price | ② | Retailer obligations | ③ | Bilateral agreements | ④ | <table border="1"> <tr><td>OTC</td><td>①</td></tr> <tr><td>ETFs</td><td>②</td></tr> <tr><td>Local hedges</td><td>③</td></tr> <tr><td>Day-ahead</td><td>×</td></tr> <tr><td>Intra-day</td><td>×</td></tr> <tr><td>Real-time</td><td>✓</td></tr> </table> | OTC | ① | ETFs | ② | Local hedges | ③ | Day-ahead | × | Intra-day | × | Real-time | ✓ | <table border="1"> <tr><td>Service</td><td>Procurement</td><td>Cost recovered from</td></tr> <tr><td>Contingency Reserve</td><td>Instantaneous Reserve 6s & 60s; co-optimised with energy; Over frequency reserve: contracted</td><td>IR: generators >60MW pro-rated to injection, HVDC owner; OFR: Tx owner</td></tr> <tr><td>Regulation</td><td>Single service: contracted then cleared ahead of energy</td><td>Loads pro-rated to offtake</td></tr> <tr><td>Inertia</td><td>N/A</td><td>N/A</td></tr> <tr><td>Black start</td><td>Contracted, availability fee + event fee</td><td>Grid owner</td></tr> <tr><td>Network support</td><td>Voltage Support considered, but none currently contracted</td><td>Affected distributors in relevant zone per peak kVar</td></tr> </table> | | Service | Procurement | Cost recovered from | Contingency Reserve | Instantaneous Reserve 6s & 60s; co-optimised with energy; Over frequency reserve: contracted | IR: generators >60MW pro-rated to injection, HVDC owner; OFR: Tx owner | Regulation | Single service: contracted then cleared ahead of energy | Loads pro-rated to offtake | Inertia | N/A | N/A | Black start | Contracted, availability fee + event fee | Grid owner | Network support | Voltage Support considered, but none currently contracted | Affected distributors in relevant zone per peak kVar |
| Auction | ① | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Administered price | ② | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Retailer obligations | ③ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Bilateral agreements | ④ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| OTC | ① | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| ETFs | ② | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Local hedges | ③ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Day-ahead | × | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Intra-day | × | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Real-time | ✓ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Service | Procurement | Cost recovered from | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Contingency Reserve | Instantaneous Reserve 6s & 60s; co-optimised with energy; Over frequency reserve: contracted | IR: generators >60MW pro-rated to injection, HVDC owner; OFR: Tx owner | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Regulation | Single service: contracted then cleared ahead of energy | Loads pro-rated to offtake | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Inertia | N/A | N/A | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Black start | Contracted, availability fee + event fee | Grid owner | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Network support | Voltage Support considered, but none currently contracted | Affected distributors in relevant zone per peak kVar | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <p>Retail competition ①</p> <p>Threshold ②</p> <p>Metering competition ③</p> <p>Reconciliation approach ④</p> | | <p>Version number and release date</p> | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

Settlement approach:

1. Ex-ante: prices firm at time of dispatch. Ex-post: prices determined after dispatch
2. Time granularity of settlement.
3. Whether market prices are explicitly adjusted during times of scarcity.
4. Whether market prices can be adjusted where the system operator or regulator has overridden market outcomes.
5. Locational granularity of prices.
6. Extent to which prices include the effects of network congestion.

Version number and release date

Physically connected neighbouring jurisdictions



We can provide comprehensive reports on global electricity markets including market design and participation, upcoming policy and regulatory changes, and entry advice. We can also provide detailed price and dispatch forecasts for the market as a whole and for individual generators.

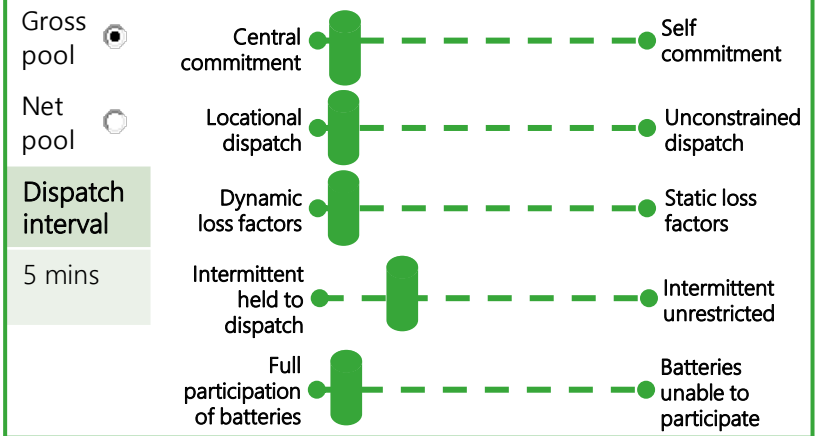
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Governance

| | |
|------------------------|--|
| Policy | Various state policy bodies |
| Regulation | Federal Energy Regulatory Commission , 14 state/district utility commissions |
| Market design lead | PJM RTO (Regional Transmission Organization) |
| Rule making | Federal Energy Regulatory Commission |
| Scheduling & dispatch | PJM RTO |
| Power system operation | PJM RTO |
| Market operation | PJM RTO |
| Metering | Allegheny Electric Cooperative , American Municipal Power , and other load servers |
| Network planning | PJM RTO |
| TX owner | AES Ohio , Appalachian Power Co , and 12 others |
| DX owner | Allegheny Electric Cooperative , American Municipal Power , and 41 others |

ELECTRICITY MARKET SUMMARY – PJM

Scheduling and dispatch

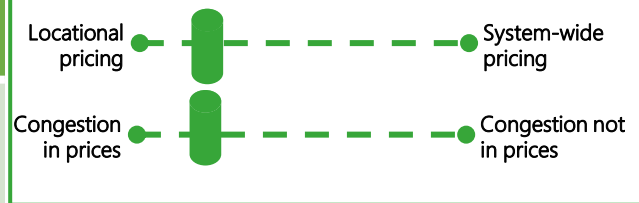


Settlement

| | |
|-----------------------|---------|
| Final prices | Ex post |
| Trading interval | 5 mins |
| Energy price floor | - |
| Energy price ceiling | \$2000 |
| Reserve price floor | - |
| Reserve price ceiling | \$1700 |
| Scarcity pricing | ✓ |
| Intervention pricing | ✗ |

Inter-connects

MISO, NYISO, TVA, LGEE, CPLE, CPLW, DUKE



Ancillary services

| Service | Procurement | Cost recovered from |
|---------------------|--|------------------------|
| Contingency Reserve | Primary reserve (synchronized and quick start) and Supplemental reserve co-optimized with energy | Tx Customers |
| Regulation | Bilateral/market: Reg-A (slow) & Reg-D (fast) co-optimized with energy | |
| Inertia | No separate market | - |
| Black start | Contracted | Tx owner and customers |
| Network support | Contracted: Reactive Supply/Voltage Control from capable generators | Tx Customer |

| Capacity | Auction | ✓ | Contracts | OTC | ✓ |
|----------|----------------------|---|-----------|-------------------|---|
| | Administered price | ✗ | | ETFs | ✓ |
| | Retailer obligations | ✗ | | Locational hedges | ✓ |
| | Bilateral agreements | ✓ | | Day-ahead | ✓ |
| Spot | | | Spot | Intra-day | ✗ |
| | | | | Real-time | ✓ |

| Retail | Retail competition | ✓ | Threshold | 0.1 MW | Metering competition | ✗ | Reconciliation approach | - |
|--------|--------------------|---|-----------|--------|----------------------|---|-------------------------|---|
|--------|--------------------|---|-----------|--------|----------------------|---|-------------------------|---|

