

2-4-C

THE ENERGY MARKET SIMULATOR

2-4-C is:

- a proven electricity market simulation model
- fast, reliable and cost effective
- capable of modelling virtually any electricity market or grid
- highly scalable, capable of performing short-term to long-term forecasting
- highly sophisticated and detailed, delivering the most credible dispatch outcomes
- integrated with ROAM's long term planning (LTIRP) and AC power flow models
- used by market operators and market participants
- used by ROAM Consulting in almost all our consulting activities

SIMULATION

- Energy prices
- Generator volumes
- Operating patterns
- Transmission flows and congestion
- Renewable energy impacts

ROAM'S CLIENTS

- Generators
- Retailers
- Transmission operators
- Market operators
- Market regulators
- Government bodies
- Industrial energy users
- Project developers

ROAM Consulting's flagship product 2-4-C provides highly accurate simulation of the physical and financial operation of the Australian National Electricity Market (NEM), and other markets and grids such as the Western Australian Energy Market (WEM).

Since soon after the start of the Australian National Electricity Market (NEM) in 1998, ROAM Consulting has been providing forecasts to nearly all NEM participants including retailers, generators, transmission operators, government bodies, regulators, and market operators AEMO and IMO (WEM operator).

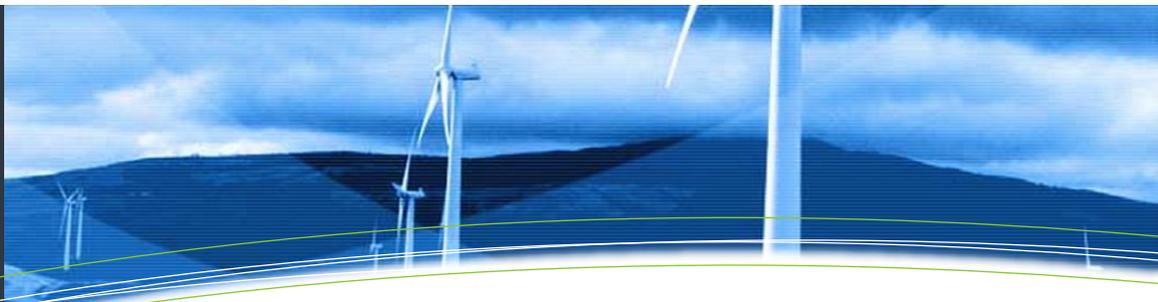
This forecasting is made possible by ROAM Consulting's own 2-4-C market simulation software. The software was developed and is maintained entirely in-house and has been continually improved to keep up with the constantly changing nature of today's markets and the demands of those needing to understand it.

The 2-4-C dispatch engine is able to replicate most functions of AEMO's own real-time dispatch engine (NEMDE), meaning that 2-4-C is capable of simulating real market behaviours to the most rigorous level of detail possible with public data.

2-4-C's ability has been proven time and time again, in roles such as 'shadowing' key studies performed by AEMO. 2-4-C has been the model of choice used to determine the Minimum Reserve Levels needed to meet the mandated Reliability Standard of the NEM since 2003.

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FLEXIBILITY

- Flexibility is important

- ROAM offers complete customisation services
- Input and output components can be tailored to your needs
- Not only for the NEM. 2-4-C is completely generic and can model any network or market
- 2-4-C can be fully imported from PSSE powerflow files with an optional module

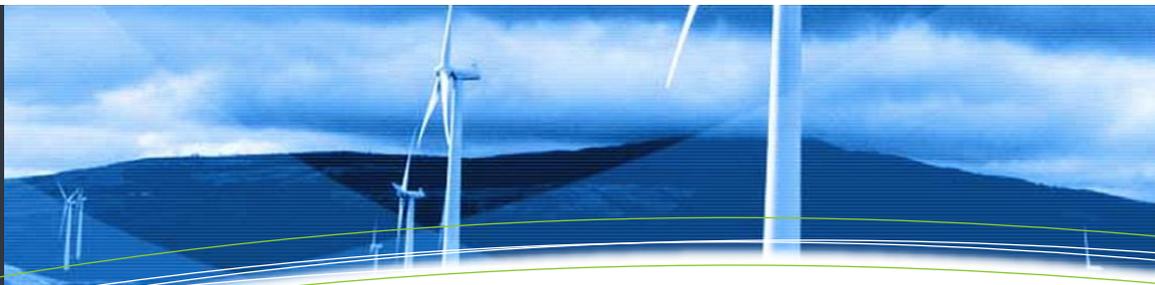
2-4-C Example Uses

- Forecasting wholesale energy prices, generation volumes and operating patterns
- Assessment of bidding strategies
- Determining carbon pricing impacts on volumes, prices and operating patterns
- System reliability modelling
- Assessment of rule change impacts or regulatory changes
- Assessing transmission congestion
- Impacts of renewable generators on market prices, transmission flows and congestion



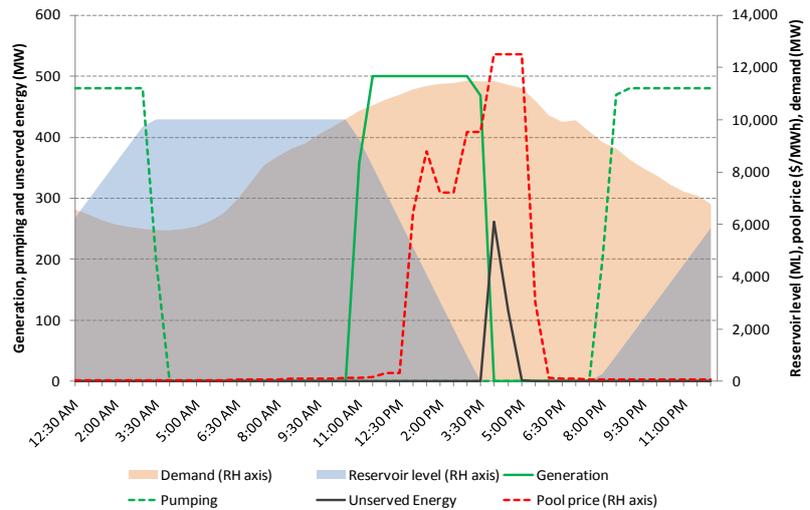
2-4-C Key Features

- Detailed model of power system down to individual generating units and transmission links
- Supports models in the order of thousands of nodes and regions
- Resource management including fuel/stockpile limits
- Generator technical constraints and planned/forced outage modelling
- Transmission planned/forced outage modelling
- Case and sensitivity management
- Model the energy market only or, for the highest detail, 2-4-C supports co-optimisation with ancillary services (e.g. FCAS) markets
- Variable time resolution modelling, from 5 minute dispatch through 30 minute trading intervals or longer
- Sophisticated hydro system modelling including pumped storage and cascades
- Advanced dispatch behaviours including tie-breaking and others
- Full generic transmission constraint equation modelling, including thermal, voltage and transient stability
- Massively scalable processing options. Run on one machine, or distribute over a hundred CPUs or more to parallelise computation and get large simulations tasks done quickly and efficiently
- Free solver engine option (CLP) and commercial solver option (Xpress)
- *Optional* Dynamic Bidding module including 'race to floor' and other behaviours
- *Optional* support for NEMDE 'RPN' format constraints, enabling direct comparison with NEMDE operation
- *Optional* medium term optimisation module (**H2Opt**) for optimisation of energy limited plant, including complex hydro systems such as pumped storage and cascaded hydro systems, plus solar thermal and battery storage technologies
- *Optional* DC load flow transmission constraints model
- *Optional* SC-OPF (Security Constrained Optimal Power Flow) transmission constraints model



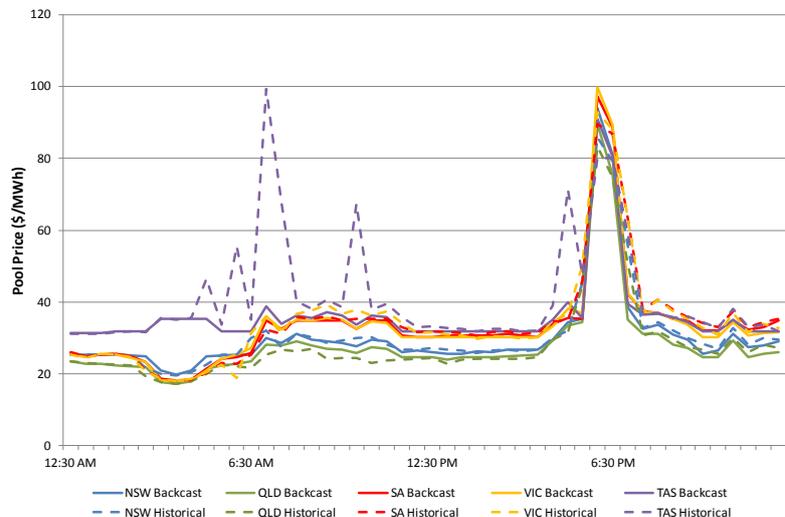
Example Outcomes

2-4-C has sophisticated plant models, including pumped storage. This figure shows a 2-4-C model of the Wivenhoe pumped storage system. Pumping occurs in the overnight lower-priced periods, and generation occurs during the mid afternoon when demand and prices are highest based on bids and offers. In this example, prices reach a high enough level such that Wivenhoe is dispatched from 11:00 am. As it operates, it quickly empties the upper reservoir, such that by 3:30 pm, the reservoir is empty and no more generation can occur. Here, the demand is still high, and with Wivenhoe effectively no longer available, the Queensland region hits the Market Price Cap of \$12,500/MWh briefly, and some Unserved Energy is recorded as there is insufficient generation to meet the demand.



If reservoir limits like this example are not taken into account, a simplistic model may allow Wivenhoe to run throughout the entire high demand period, meaning the reliability of the system would be overstated and the pricing outcomes would not be as volatile.

Backcasting is notoriously difficult to do with high accuracy (and some aspects are impossible with only public information). This example output shows a 2-4-C backcast against real historical NEM prices for 9/5/2011, in which 2-4-C is able to predict the evening price spike with a high level of accuracy (unique aspects of the HVdc interconnector into Tasmania were not modelled in this example). The power and detail of 2-4-C allows real historical analysis; a powerful tool for examining 'what if' scenarios on real market information. Optional modules for 2-4-C allow the user to automatically configure real NEM data (from AEMO) to efficiently perform a backcast of any point in the history of the NEM. From there, the user can change parameters such as bids, availability and so forth to understand those 'what ifs'.



MANAGEMENT

- Job Management

- Control your simulations through a regular web browser
- Supports multiple users
- Many results available through web interface
- Full job tracking with email notifications

- Scalable

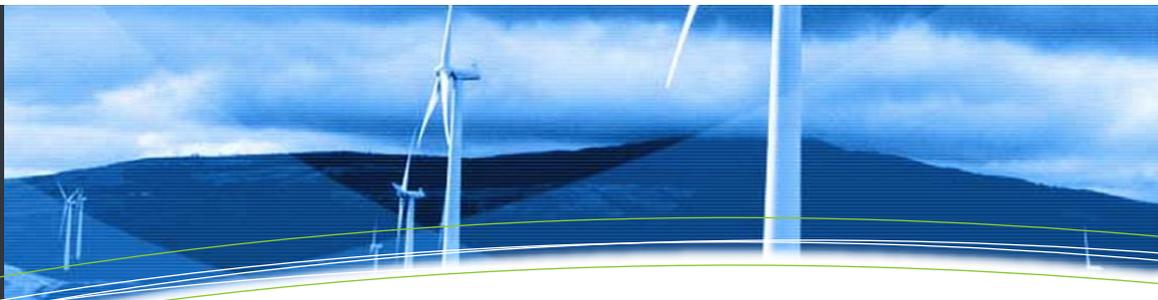
- Run your simulations on any number of client PC's
- Lightweight client install
- Switch between processing 2-4-C jobs and regular PC use with one click

- Accessible

- All job data including input and output available in standard SQL databases
- Supports access via any compatible database/SQL tools
- All market element results computed and stored every time. No need to rerun the whole simulation because you omitted an output option you later wanted.

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TECHNICAL SUPPORT

A full year of technical and modelling support is provided with every 2-4-C licence.

LICENCE OPTIONS

Single and multi-user 'site' licence options are available. Desktop-based and distributed client-server models available.

ALSO INCLUDED

To get you up and simulating quicker, 2-4-C comes pre-loaded with a base data set tuned using ROAM's extensive experience and market knowledge.

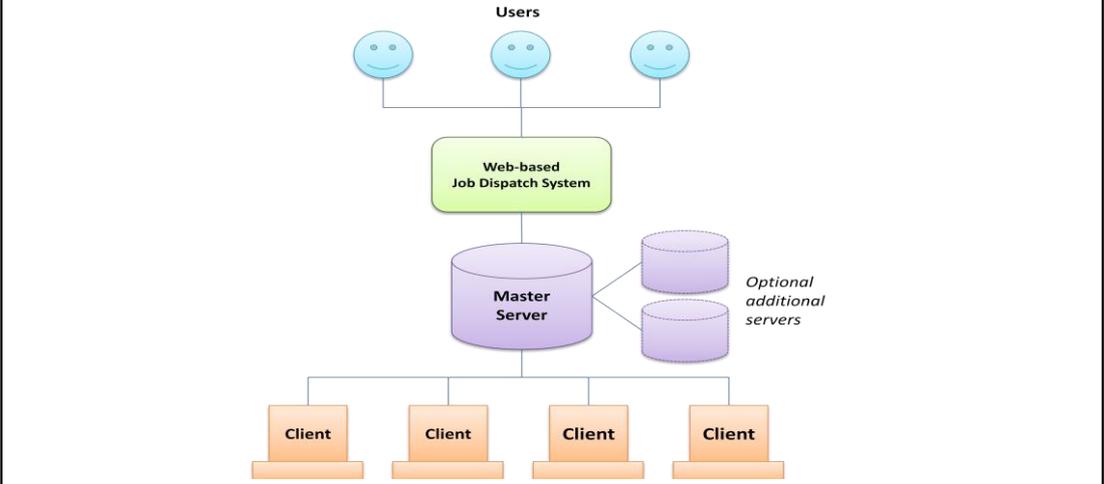
Also included are easy-to-use Excel-based result analysis tools to allow you to analyse your results quickly and efficiently with the familiarity of Excel.

For more information on any of our products or services please visit us on the Web at: www.roadconsulting.com.au or contact us as below.

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2-4-C Distributed System Architecture

2-4-C is massively scalable. Simulations can be distributed over many client computers. Doubling the number of CPUs roughly halves the computation time needed. These clients need not even be dedicated machines. Regular desktop machines can perform 2-4-C simulations while they aren't occupied with other tasks. ROAM's Job Scanner service and web-based Job Dispatch System gives complete control over your simulations. This diagram shows how it all fits together:



Further Information

To find out more information about 2-4-C including licensing or demonstration, please visit ROAM:

- on the Web at roadconsulting.com.au
- or email us at info@roadconsulting.com.au

Some of ROAM's many other services

- Marginal Loss Factor (MLF) and Distribution Loss Factor (DLF) forecasting and powerflow analysis
- Price forecasting including wholesale energy, contract pricing and retail pricing, short-term and long-term
- Transmission connection option assessment
- Regulatory Investment Testing (RIT-T)
- TUoS (Transmission Use of System) assessments including avoided TUoS analysis
- Congestion analysis including constraint equation construction
- Long term planning including co-optimisation of generation and transmission
- Assessment of carbon pricing and emissions trading impacts
- Expert witness duties involving market analysis
- Renewable energy modelling including RET scheme forecasting, wind and solar plant generation
- Short-term wind power generation forecasting, including large rapid changes in wind power
- Regulatory assessment including rule changes
- Modelling other electricity markets including WEM, NZEM and others
- Modelling of non-market systems including remote grids

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