Locating wind farms to improve wind contribution in a high penetration renewable electricity system

B. Elliston, M. Kay, M. Hidas, I. MacGill

University of New South Wales
Sydney, Australia

Outline

- Background: simulated 100% RElec scenarios

- Current wind power sites & performance

- How could wind output improve?

- Modelling other NEM sites with TAPM

- Conclusions

# 100% renewable electricity scenario

- Simulated 100% renewable electricity in the Australian National Electricity Market (hourly)

- System comprises available technologies (wind, PV, CST, hydro, biofuel GT)

- A range of 100% renewable electricity systems can meet the NEM reliability standard in 2010

- Principal challenge: meeting peak demand on winter evenings
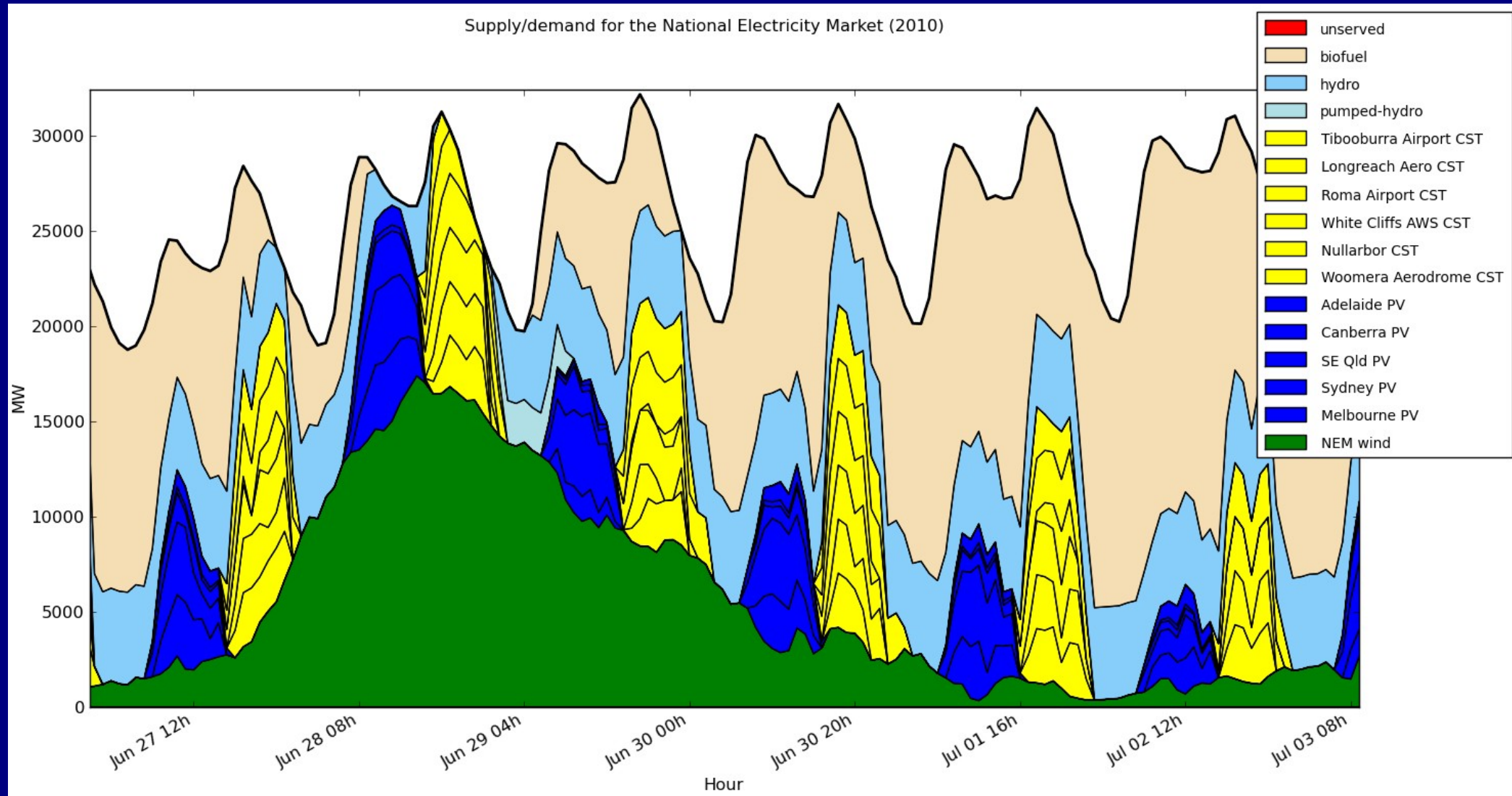
Existing significant NEM wind farms

Map generated using Google Maps and JavaScript adapted from A. Miskelly
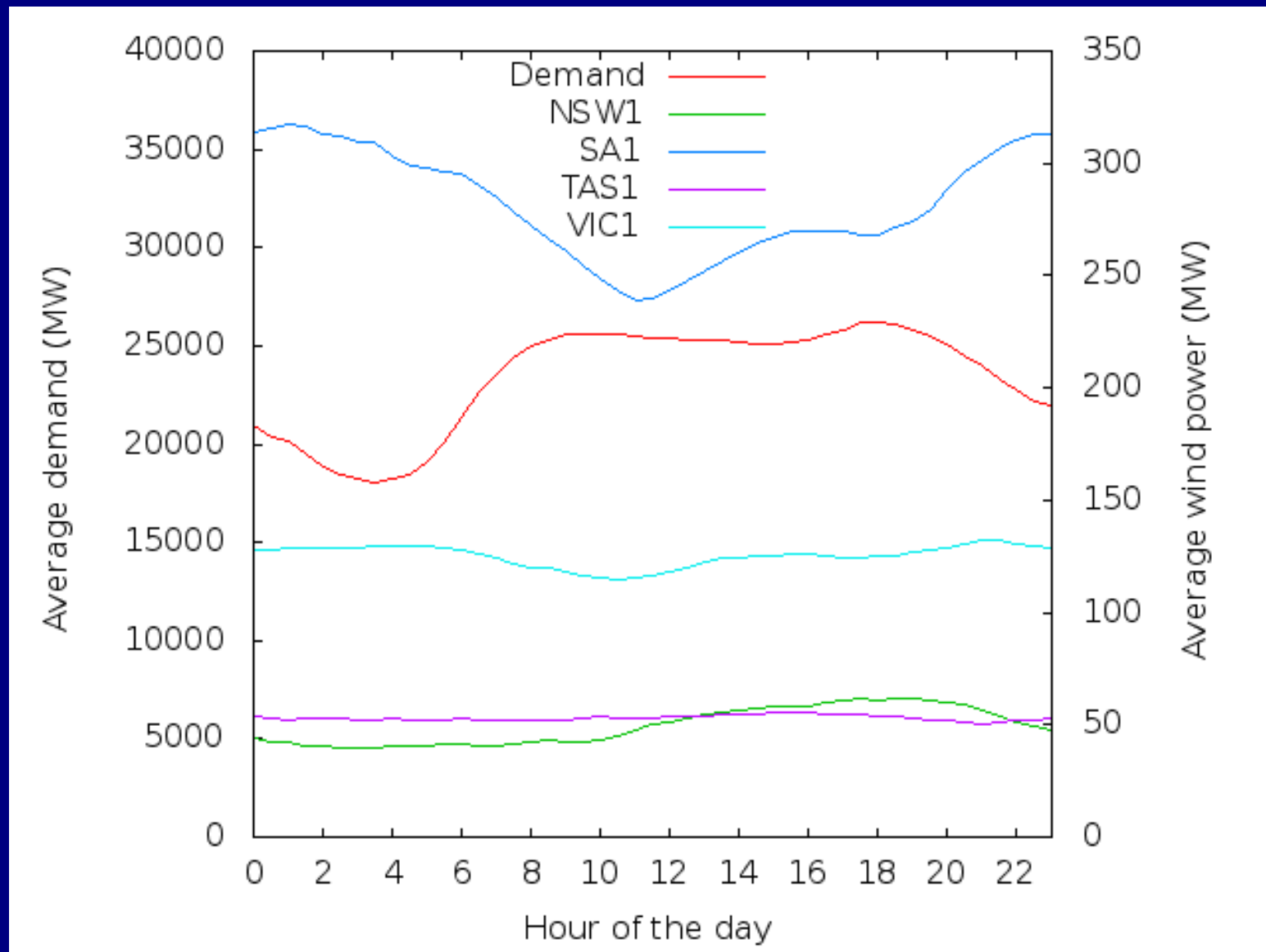
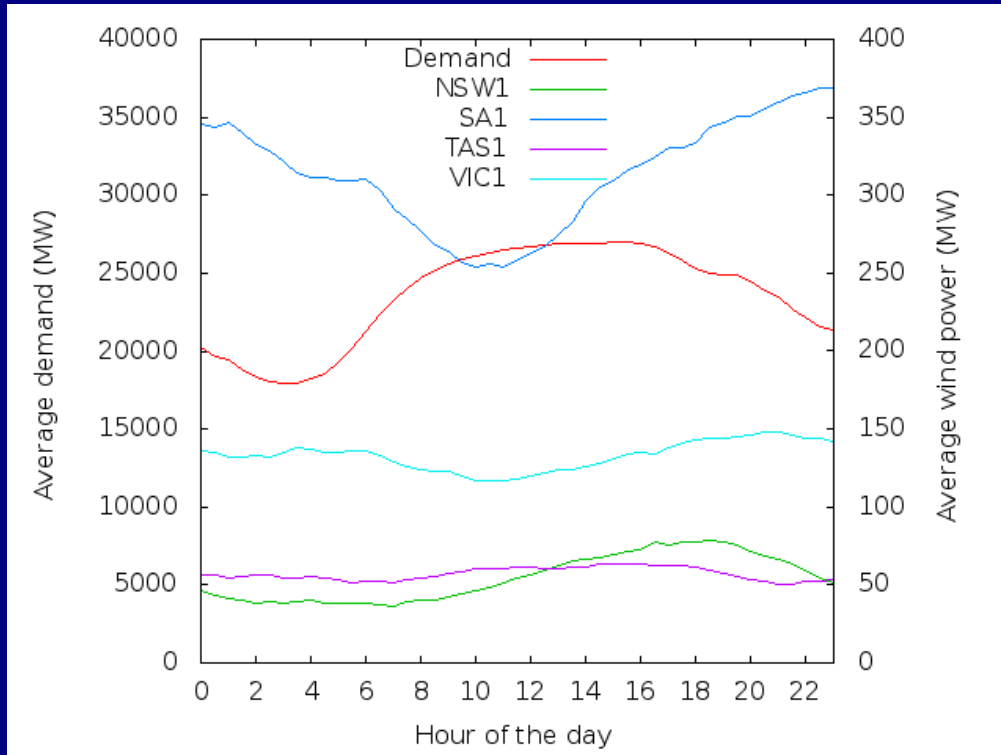# Simulation results: January 2010

Supply/demand for the National Electricity Market (2010)
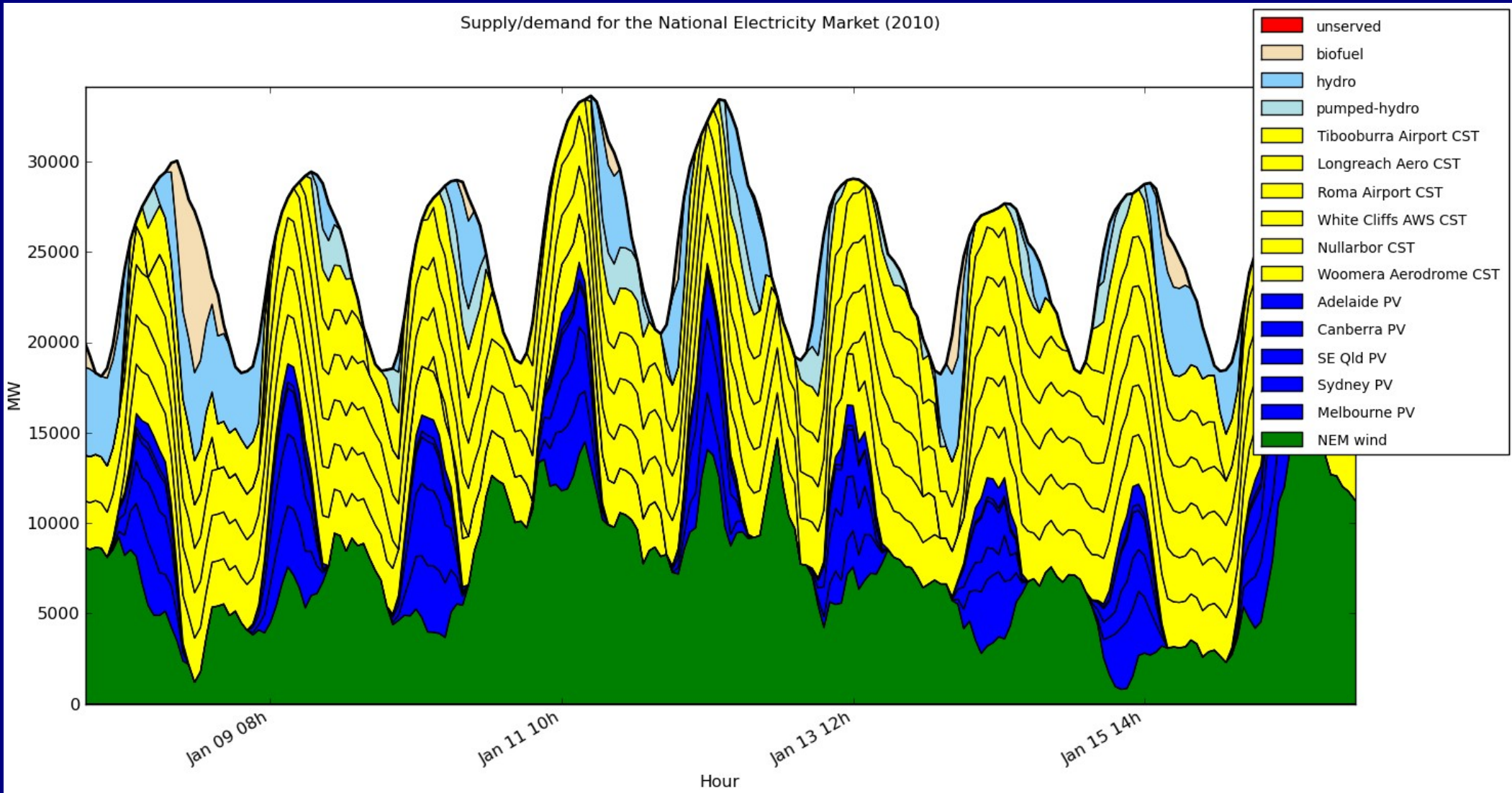
Simulation results: June/July 2010

Supply/demand for the National Electricity Market (2010)
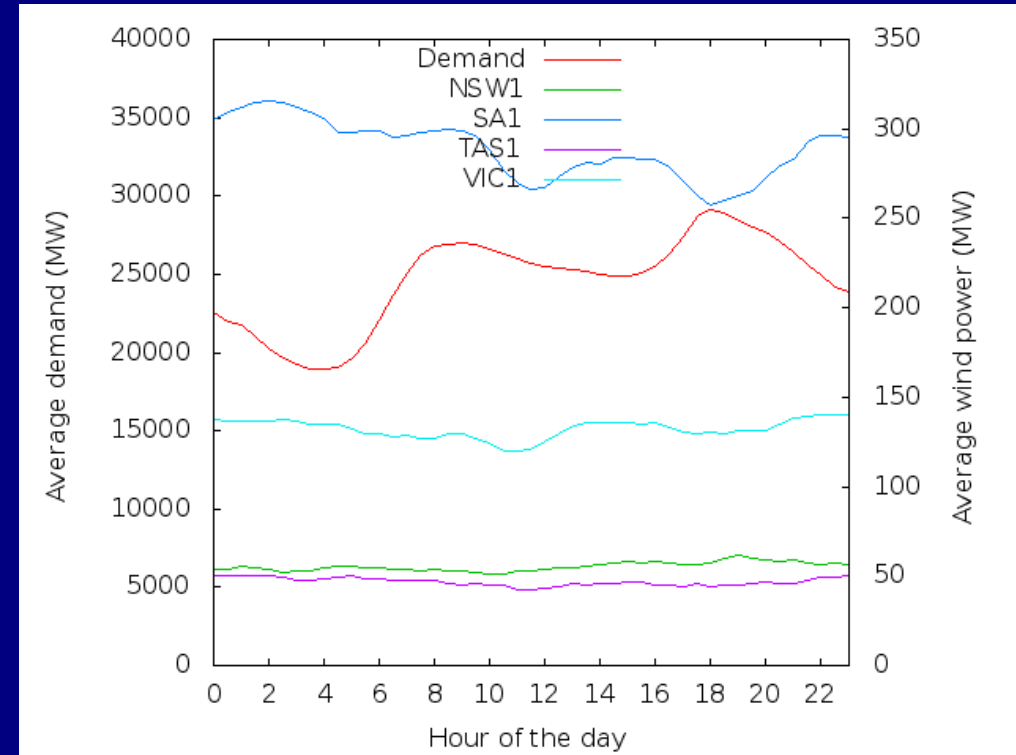
Regional wind power superimposed on aggregate NEM demand (2010)

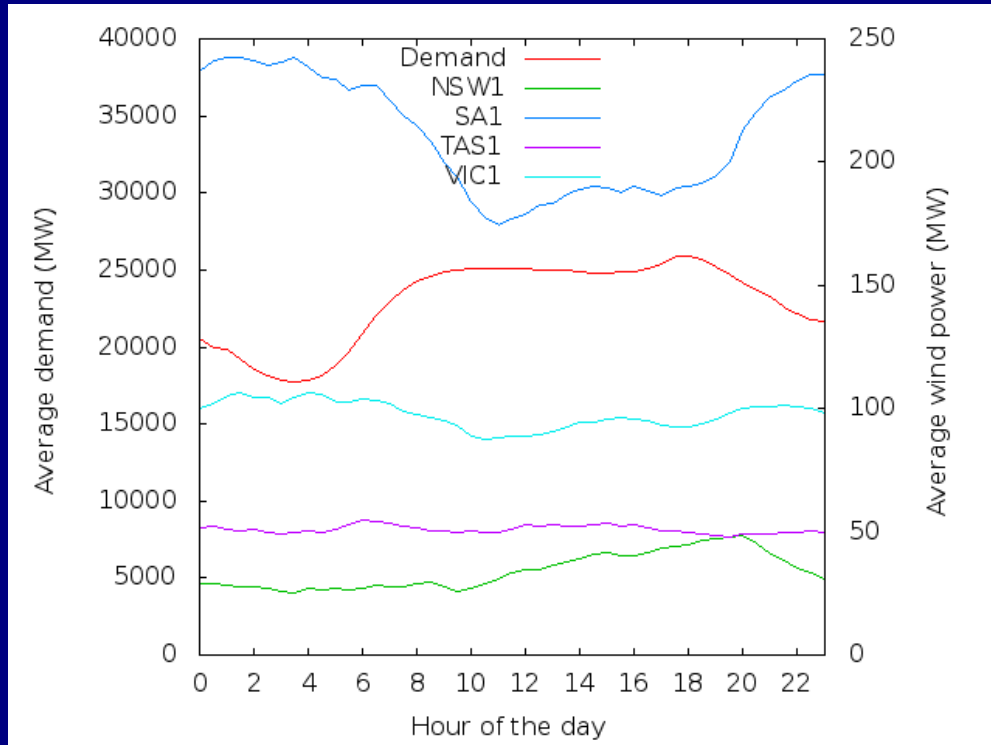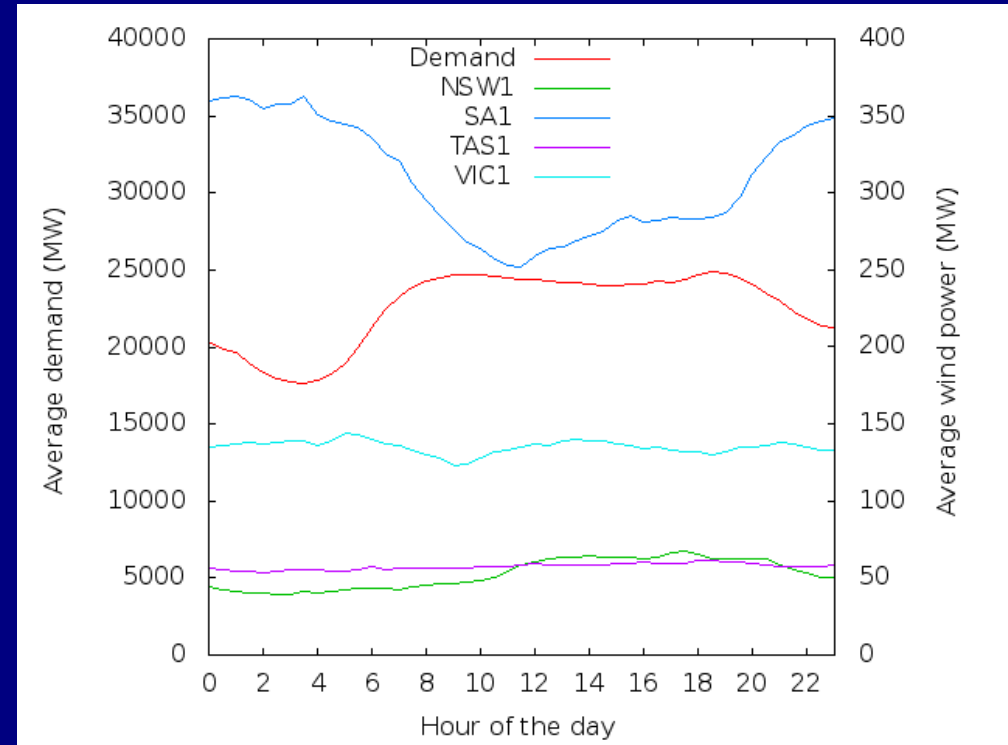# Cross-correlations by season

Summer

Winter

Cross-correlations by season

Autumn

Spring

How could wind output improve?

- Existing wind farms in NEM poorly correlate with demand
- Wind may contribute little during peak periods
  (eg cold & still winter evenings)
- In a 100% renewable system,
  - ↑ capacity factor = ↑ energy from wind, less from other sources
  - ↓ correlation with demand = ↑ probability of requiring dispatched power
- More consistent and correlated wind output would:
  - Reduce in biofuel use
  - Reduce GT generating capacity
- Two goals:
  - ↑ Capacity factor, more wind energy
  - ↑ Correlation with demand (provide it when needed!)

The Air Pollution Model (TAPM)

- Windows software developed by CMAR

- Main function: "estimate spread and impact of air pollution"

- Models key meteorology variables in a local area using terrain, land use and synoptic data

- Up to 5 nested domains at varying resolution

- Can produce hourly time series

- Excellent coverage for wind speed data

Sites chosen beyond existing NEM wind sites (excluding Hallett)

Spatial correlation of hourly wind around Hallett – January 2010
(1100km x 1100km region)
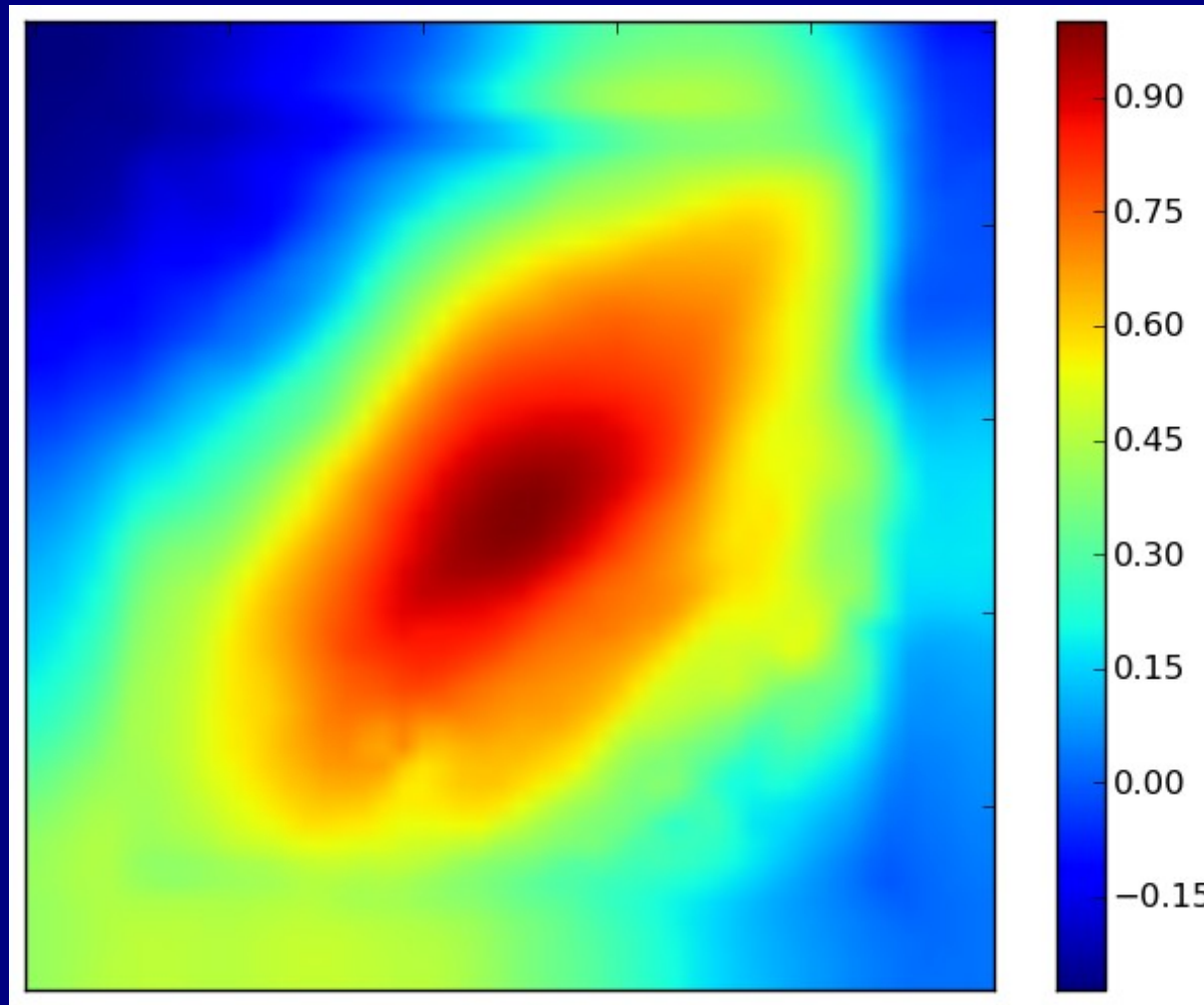
Cross-correlation between Hallett (centre cell) and neighbouring 22km x 22km cells

Exploring alternative sites

- Run TAPM model at each location

- Generate hourly wind time series at 75m height

- Time series for all months and sites generated in parallel by running TAPM on Linux

Cross-correlation of wind speed: sites with Hallett (modelled)

	January	February	June	July	August
Condoblin, NSW	0.16	-0.07	0.49	0.61	0.42
Longreach, QLD	-0.21	0.03	0.09	0.10	-0.07
Cooranga, QLD	0.06	0.10	0.16	0.44	0.03
Hughenden, QLD	-0.07	0.09	0.10	0.12	-0.09
Myall Lake, NSW	0.07	0.14	-0.16	0.01	-0.05

Cross-correlation of 2010 hourly wind speed time series with Hallett, SA

Mean wind speed by month (modelled)

	January	February	June	July	August
Condoblin, NSW	4.79	5.12	4.11	4.01	5.59
Longreach, QLD	4.93	4.75	4.33	4.67	4.86
Cooranga, QLD	6.80	7.55	5.29	6.13	6.10
Hughenden, QLD	6.98	6.22	6.21	7.08	6.36
Myall Lake, NSW	4.51	5.18	5.49	4.98	6.68
Hallett, SA	6.42	6.24	5.64	6.33	7.97

metres per second at 75m height

Mean 6 pm wind speed by month (modelled)

	January	February	June	July	August
Condoblin, NSW	4.76	4.57	3.87	3.91	5.55
Longreach, QLD	4.79	4.88	4.13	4.34	4.69
Cooranga, QLD	6.02	6.80	4.68	4.90	5.71
Hughenden, QLD	6.22	5.40	5.05	5.67	5.28
Myall Lake, NSW	4.71	5.63	5.10	5.06	6.54
Hallett, SA	6.05	5.58	5.51	6.17	7.29

metres per second at 75m height

Next steps

- Validate TAPM wind data against other sources

- Examine a wider range of sites

- Simulate wind farm output using SAM

  - Utility-scale wind farms since version 2011.5.4

  - Simple "SWRF" file format

- Optimise wind farm siting and generating capacities in the energy system simulation

Conclusions

- Sites far from existing NEM wind farms (1000+ km) have favourable, weak cross-correlation with existing sites

- Some Queensland sites warrant further investigation for wind turbine simulation

- Some distant sites poor overall in 2010

- No stand-out sites for exceptional evening winds in winter 2010

Acknowledgements

- Australian Solar Institute
- Intersect Australia
- NCI National Facility

Questions?