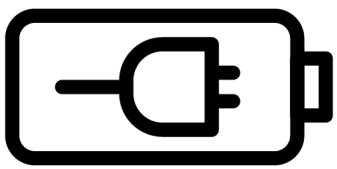
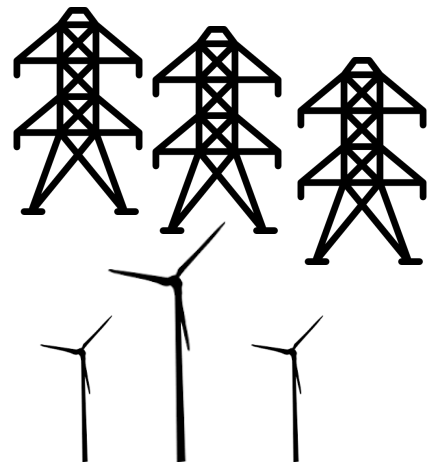
Analysis
&
Understanding



Optimisation
&
Decisions



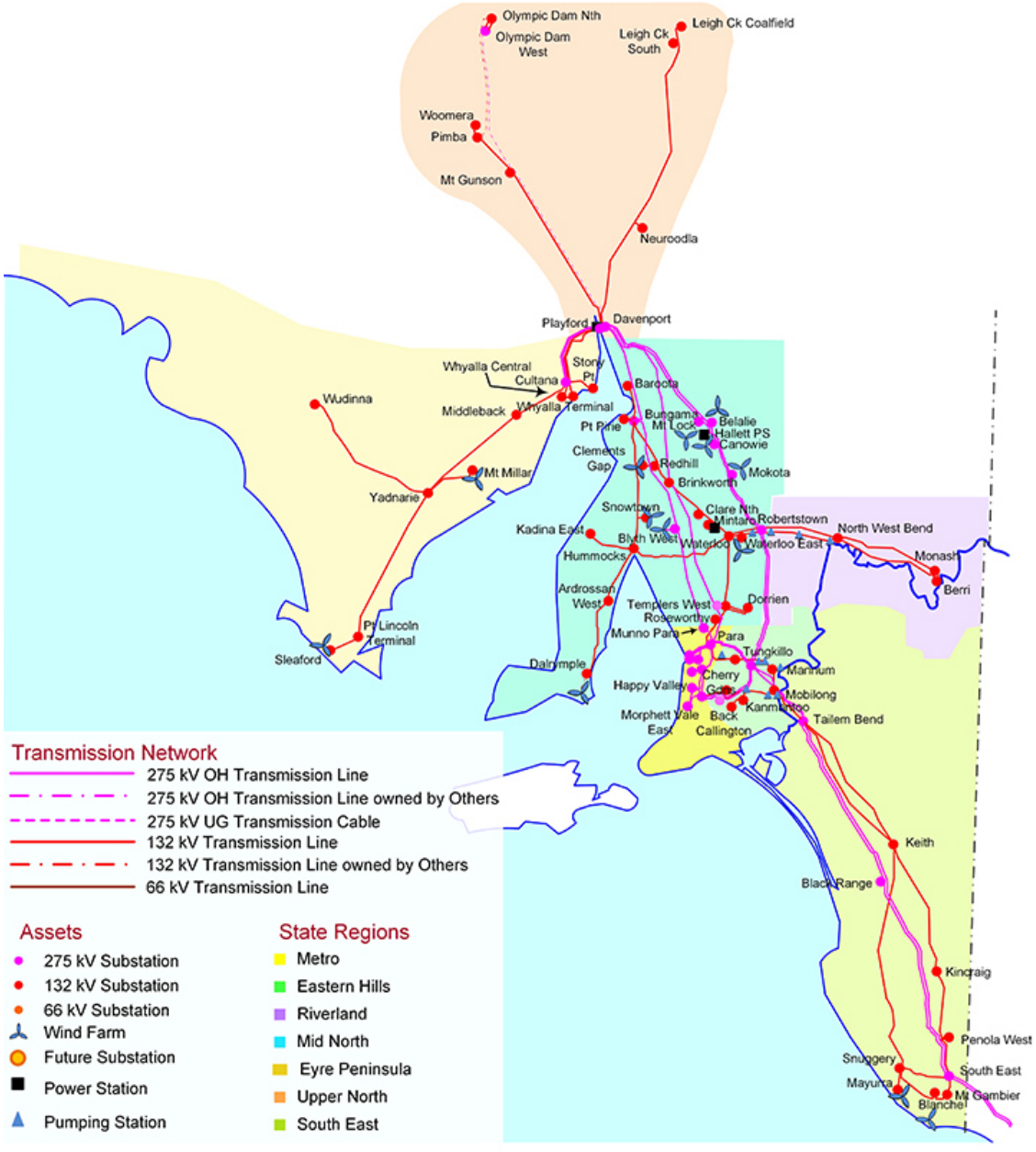
MISG

Mathematics in Industry Study Group

+

ElectraNet

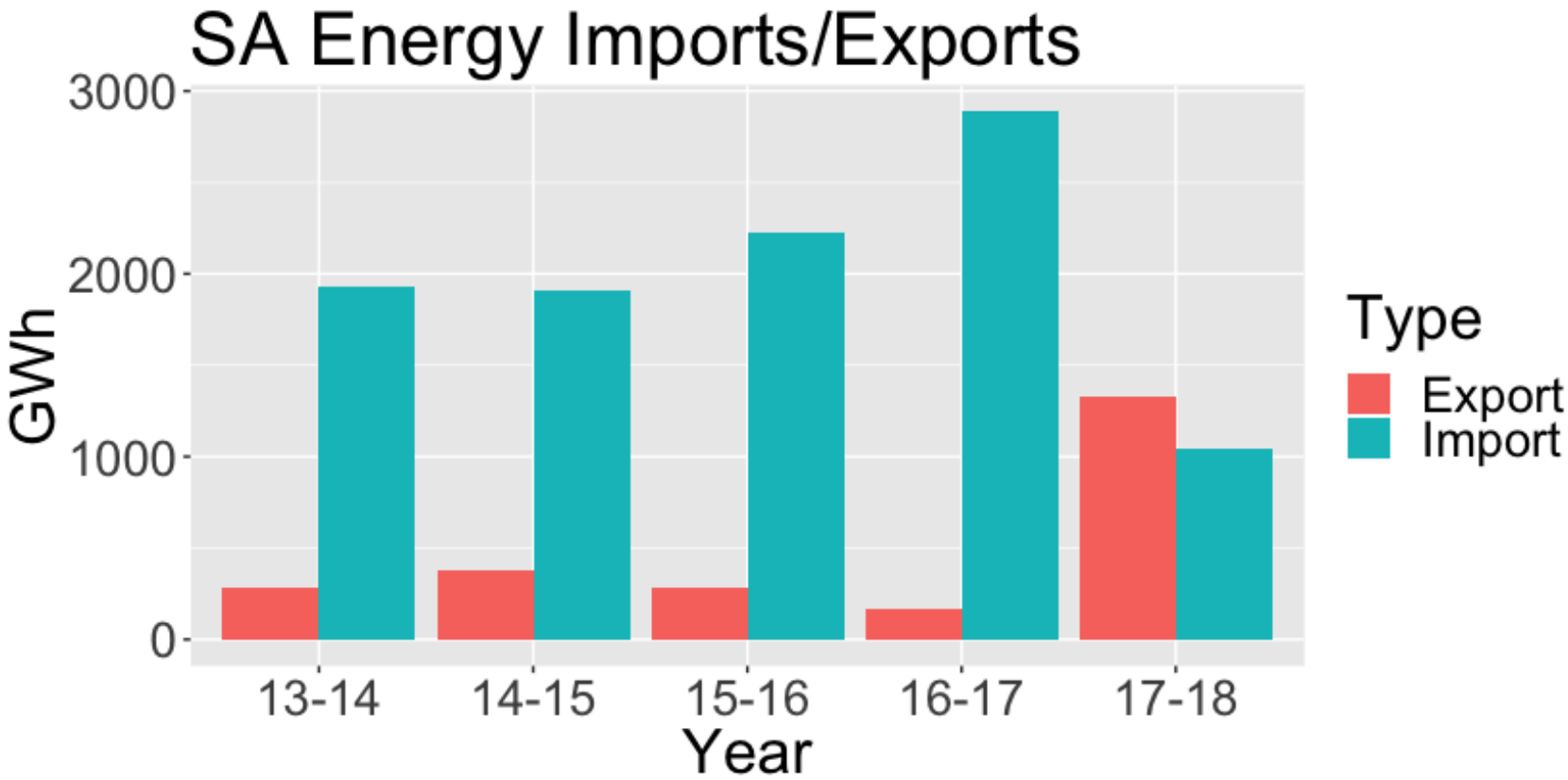
ACEMS



←Murraylink

←Heywood

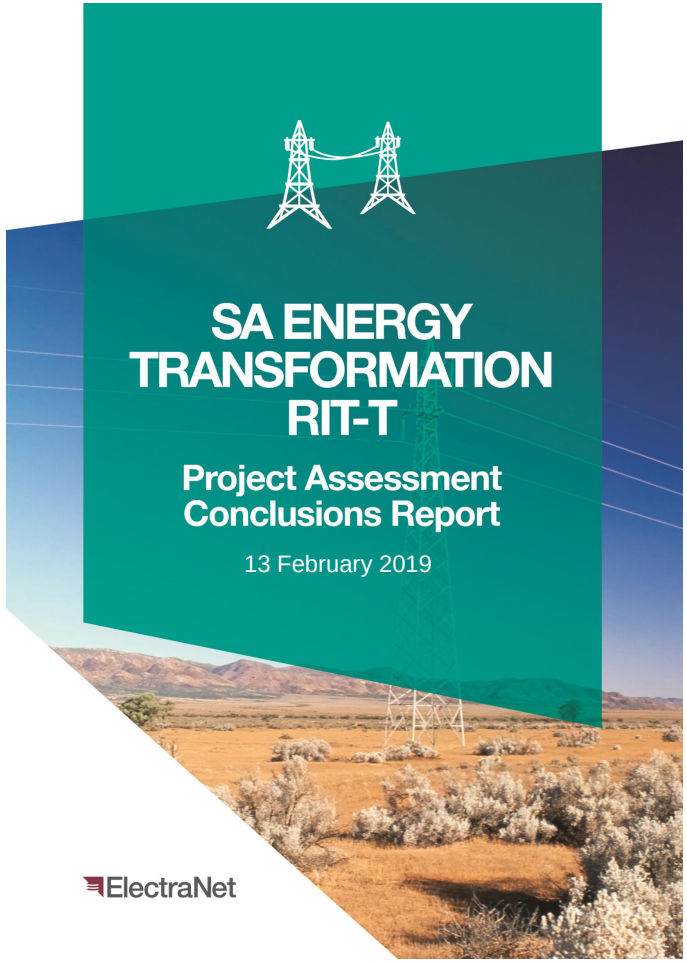
ACEMS



Total demand in SA for 2017/18 was 12,203 GWh

Source: SA electricity report

ElectraNet wanted to build another interconnector



First, to understand what ElectraNet was currently doing.

Optimisation (Linear programming)

By building generators and transmission lines

minimise Cost

subject to Supply $>$ Demand
Stability constraints

An illustrative example

In each state,

- on average, generation = 50 MW per
- demand = 100 MW in each state
- 1 generator
- No interconnector

An illustrative example

Demand $= 100$ MW
Generation $= 50$ MW

Demand $= 100$ MW
Generation $= 50$ MW

Costs

- \$50 to build 
- \$50 to build 
- Running cost  : \$1

Constraints

-  capacity: 60 MW
- Supply $>$ Demand

An illustrative example

minimise  built $\times$ \$50 $+$  operated $\times$ \$1
$+$  $\times$ \$50

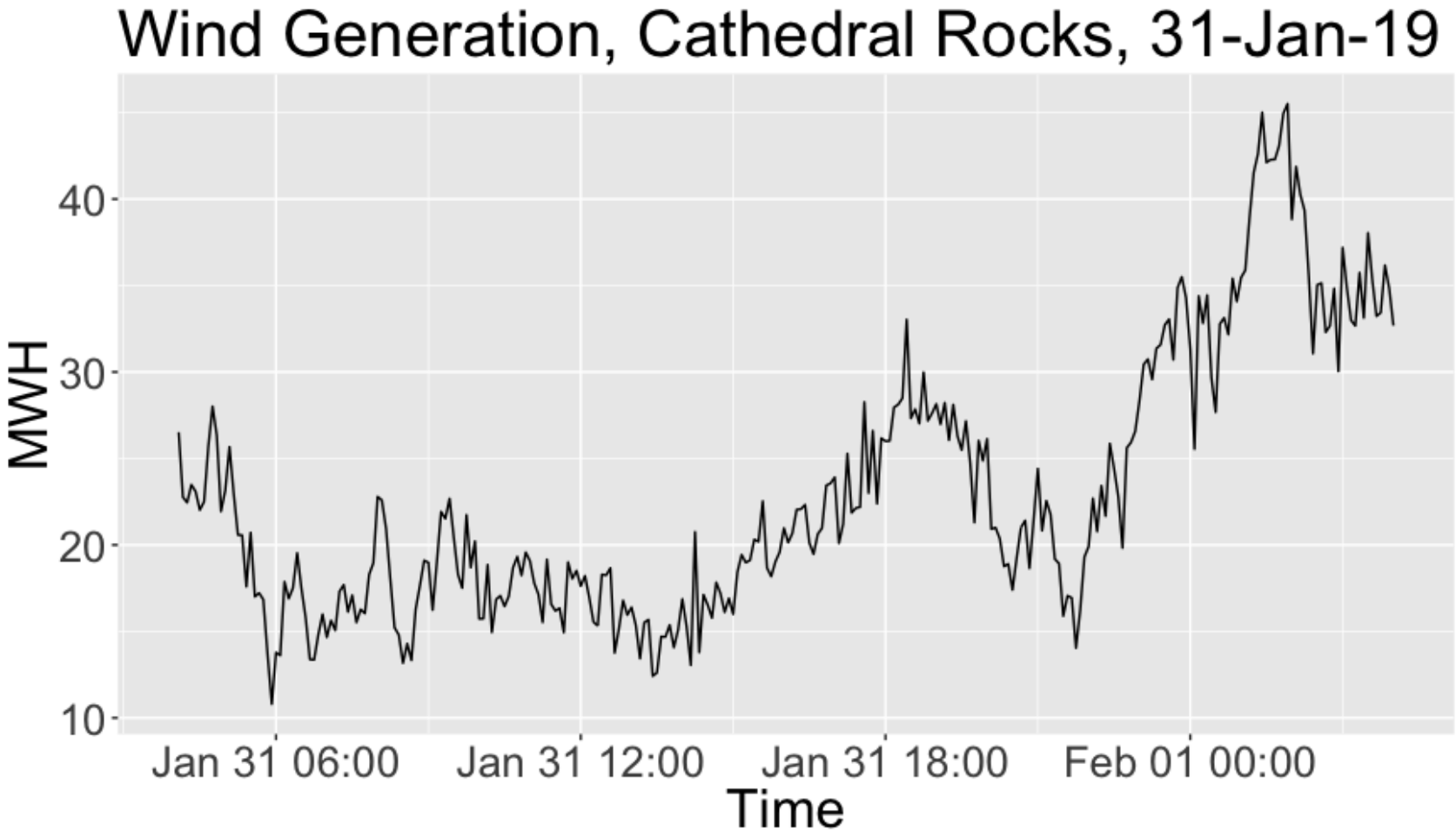
subject to Supply $>$ Demand
 Load $<$ 60 MW

An illustrative example

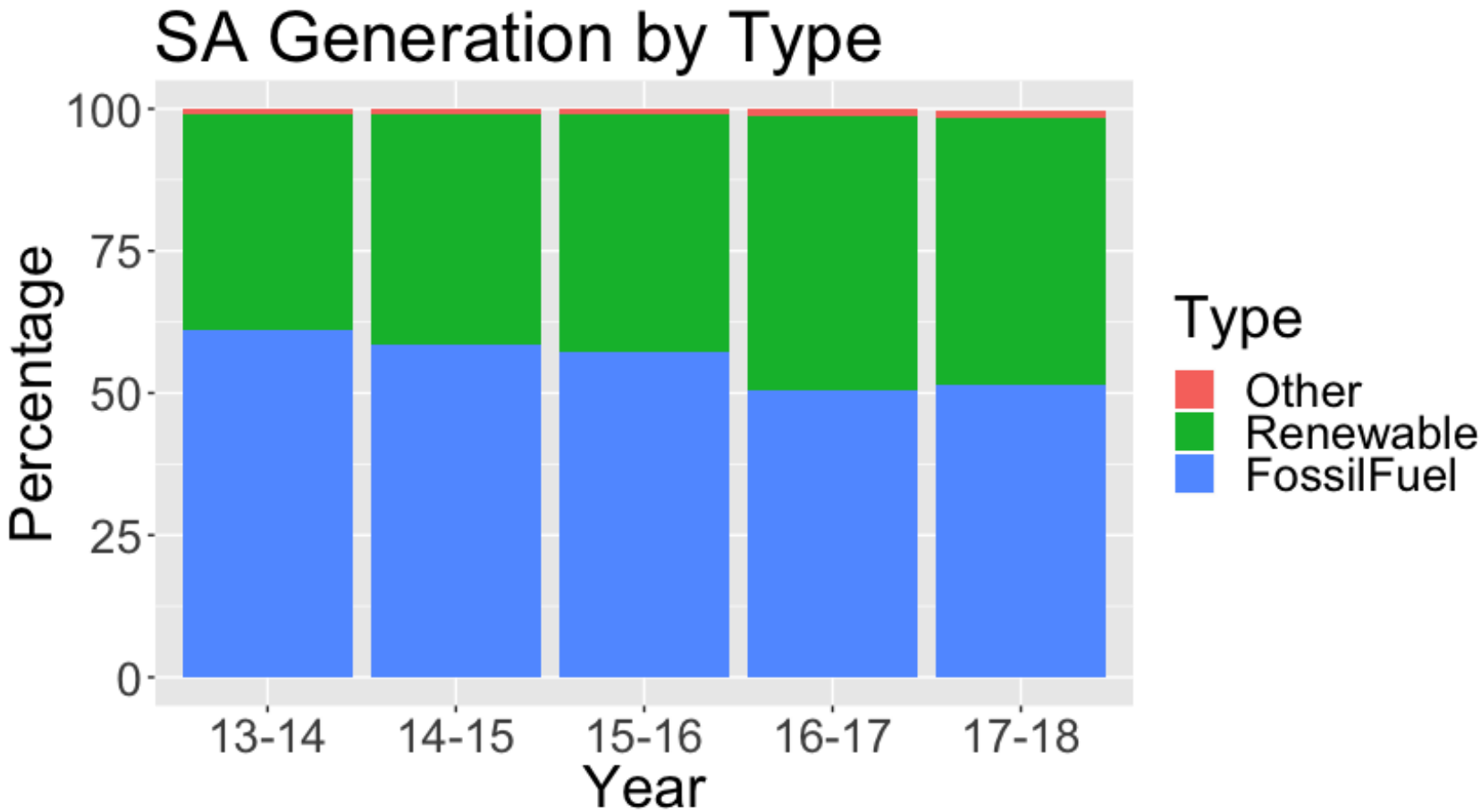
Solution

$$\text{Cost} = 2 \times \$50 + 4 \times \$1 = \$104$$

Great,
in the 1970's...

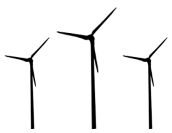

Wind Generation, Cathedral Rocks, 31-Jan-19
MWH
40
30
20
10
Jan 31 06:00
Jan 31 12:00
Jan 31 18:00
Feb 01 00:00
Time

Source: AEMO



Source: SA electricity report

Including uncertainty

	Calm in SA	Windy in SA
Generation per 	SA $= 20$ MW Vic $= 80$ MW	SA $= 80$ MW Vic $= 20$ MW

Average generation per  $= 50$MW

Including uncertainty

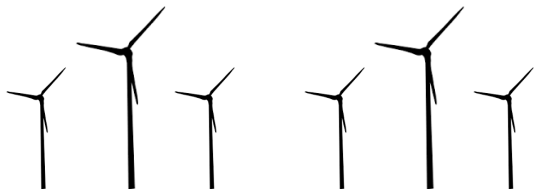
Calm Scenario

SA

Demand = 100 MW

Generation = 40 MW

Vic



Demand = 100 MW

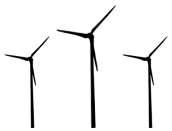
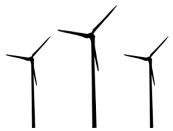
Generation = 160 MW

If short fall cost is \$1 per MW, this solution costs

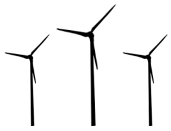
$$\$104 + 60 \times \$1 = \$164$$

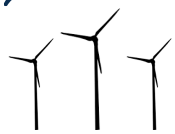
"How can we include the uncertain nature of renewables in the capital decision making?"

Accounting for uncertainty

minimise  built $\times$ \$50 +  operated $\times$ \$1
$+$  $\times$ \$50 $+$ **Average shortfall cost**

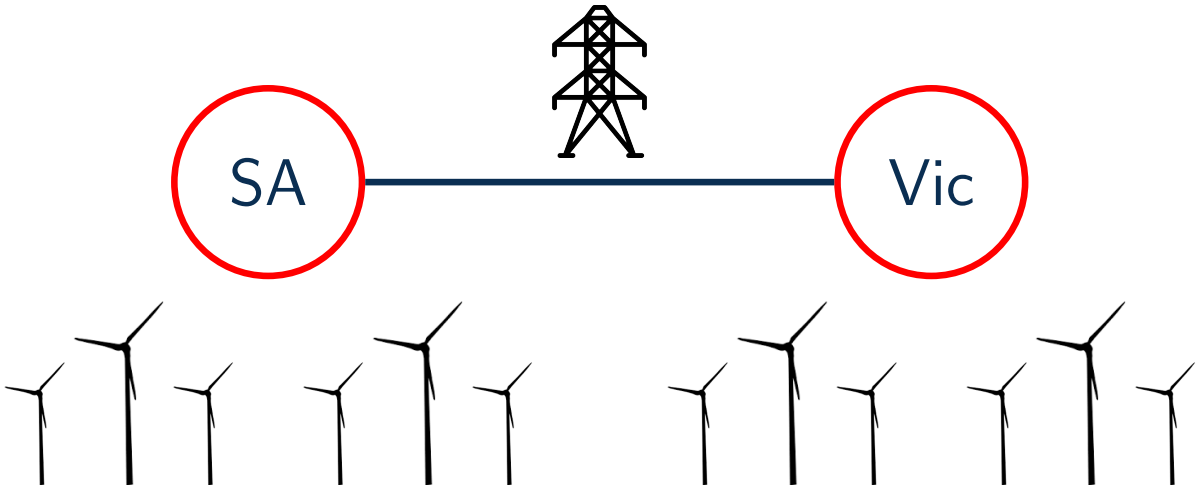
subject to Supply $>$ Demand
 Load $<$ 60 MW

Calm: generation in SA $=$ 20 MW per 

$$\text{Shortfall} = \overbrace{100\ \text{MW}}^{\text{Demand in SA}} - \overbrace{\text{  } \times 20\ \text{MW}}^{\text{Generation in SA}} - \text{Imports}$$

Accounting for uncertainty

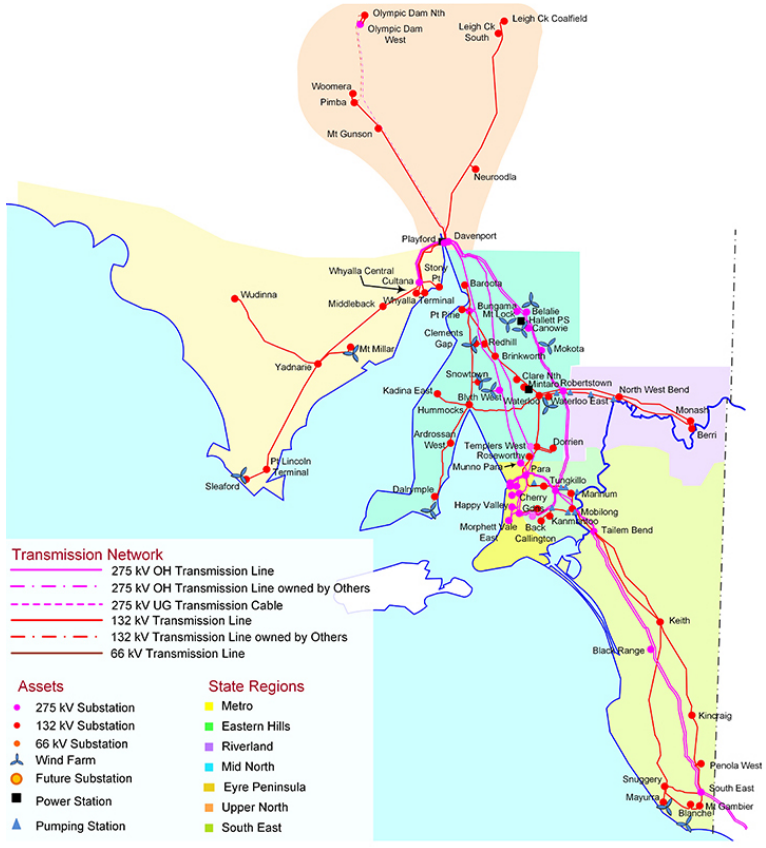
Solution



- No shortfall
- Cost is $\$50 + \$50 + \$50 + \$4 = \$154$
- Compare to the previous solution: costs \$164
- Realise interconnector value

Life-size problems

- More decisions to make
  - e.g. type of generator
- More constraints
  - e.g. financial constraints
- More detailed model of generation/demand
- More detailed network
  - e.g. include NSW, QLD
  - generator-level network



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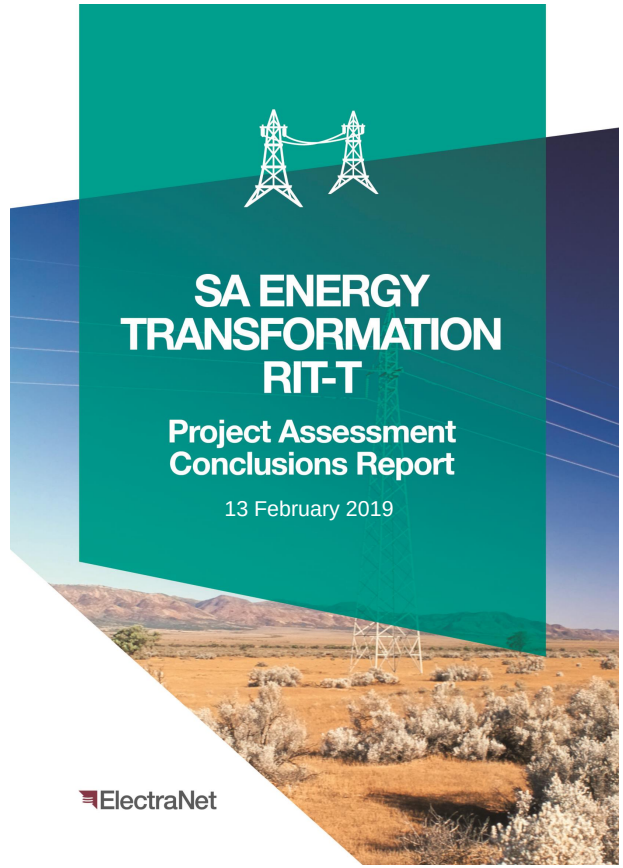
- "SA could see bills reduce by about $66 per year"
- "NSW could see bills reduce by about $30 per year"
- "The new interconnector could also, improve network and energy security, and support transformation towards a lower carbon emissions future"



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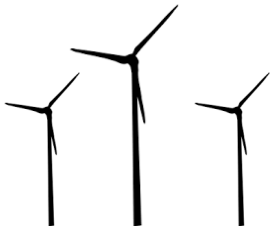
wind/solar/ demand forecasts

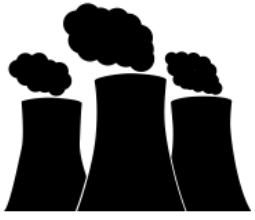


Analysis & Understanding

electricity markets

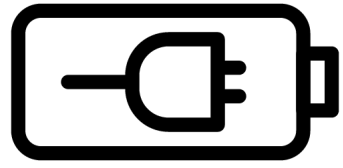
$$$

generator dispatch



Optimisation & Decisions

storage management



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ARC Centre of Excellence in Mathematical and Statistical Frontiers
(ACEMS)

https://acems.org.au/

Dennis Liu
dennis.liu01@adelaide.edu.au
Angus Lewis
angus.lewis@adelaide.edu.au