sapere research group

Calculation of the Capacity Value of Intermittent Generation
RC_2010_25 & RC_2010_37

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Note: for further details of charts and tables etc contained in this presentation refer to the following report available on the IMO website
Capacity Value of Intermittent Generation: Report by Sapere Research Group

Agenda

- Background / scope
- Approach
- Issues and recommendations
- Transition and review

Background

- Following REGWG two proposals put forward
  - RC_2010_25 - the Original IMO Proposal
  - RC_2010_37 - the Griffin Proposal
- The IMO had proposed RC_2010_25 be adopted on basis of a closer alignment with the reliability criterion...
- …but the IMO Board had some concerns, in particular with the fleet adjustment

Scope of work

- Investigate modifications to make methodologies more robust and simple
  - Determine a facility based allocation, while:
    - ensuring performance from peak periods
    - not creating too much volatility
  - Examine options for transition (a ‘glide path’)
- Considerations
  - Look for *modification* not wholesale change...
  - ... but ground changes in theory and good practice

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Meeting reliability criteria

- Reliability value of intermittent generation facility (**IGF**) is additional load that can be carried because of the IGF
- Key criterion: Probability of not meeting peak demand
  - Interested in how IGFs change distribution of surplus load
  - Potential to estimate value based on average and variability of the surplus and IGF output.

Effective Load Carrying Capability (**ELCC**) : a measure of the additional load that the system can supply with the particular generator of interest, with *no net change in reliability*.

Similar to Equivalent Firm Capacity (**EFC**), measures the capacity of a scheduled generator that would deliver the same reduction in risk.

A useful framework for analysis

Capacity credits	=	1. Average IGF output in peak periods	*Less*	2. An adjustment for the variability of IGF output
RC 37 proposal		Average IGF output in top 750 Trading Intervals (TIs)		No adjustment made
Original RC 25 Proposal		Average fleet output in top 12 TIs	*Less*	1.895 X standard deviation of average fleet output *allocated by IGF*

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  - Average output at peak
  - Adjustment to the average
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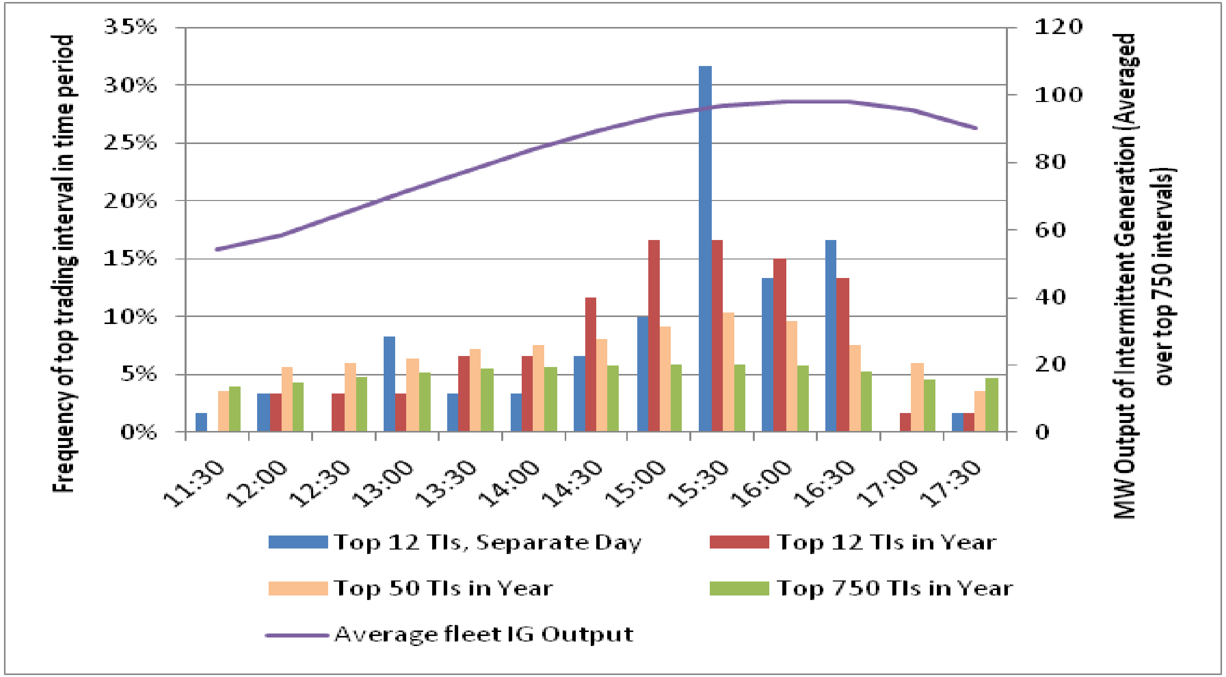
The average output at peak

- By definition really only interested in the very peak demand periods...
- ...but need to average over some trading intervals so as to reduce volatility
- Original proposals
  - Both based on top TIs in each year as measured by load for scheduled generation (LSG)
  - Original RC 25 : Top 250 for individuals, Top 12 for fleet.
  - RC 37 : Top 750 TIs

The clustering problem

- Top trading intervals drawn from similar days
  - E.g. In 2005-06 top 12 TIs all drawn from 6th & 7th of March
- Two issues with this
  1. Don’t get benefit of averaging
     - As if we selected 2 or 3 intervals
     - Result : Too much volatility in annual averages
  2. Gives biased result
     - Top TIs include periods which are unlikely to be the peak
     - A problem since intermittent generation follows patterns

The bias caused by clustering



- Peaks in a day mostly occur at 3:30pm
- Top (12,50, 750) TIs in a year under represented during this time, overrepresented at other times.
- IGF output varies significantly over day.

Solution – select from different days

- Simple solution is to select trading intervals from separate (i.e. unique) days
- Doing so enables an individual facility formula to be used drawing from peaks without much volatility
- Little evidence of IGF output being correlated between top TIs from different days

Number of trading intervals to use

- Too many trading intervals.
  - Risk that TIs are not representative of peaks
  - Only limited number of days which might be the summer peak
- Too few trading intervals
  - Risk of excess volatility
  - Risk is reduced by using additional years of data
- Recommended: 12 trading intervals x 5 years = 60 TIs
  - 12 days – all likely to be summer days which could be peaks
  - 5 years are available for most facilities

Average peak IGF output – different methods

Average MW values from top TIs (Fleet Total)		
Option Description	**Note**	**Total**
• RC 37 proposal Top 750 TIs (over 3 years)	• Large clustering problem	82.2
• Original RC 25 proposal: Top 12 TIs (Note: over ***5 years***)	• Involves a fleet adjustment • Significant clustering problem	74.8
• Require top 12 TIs to be drawn from different days (over 5 years)	• Simple • Removes clustering problem	80.2
Capacity Credits - current methodology (2012/13)		91.1

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An adjustment to the average

- Two reasons for an adjustment
  1. Intermittent generation adds to the variability of load to be met by scheduled generation
  2. Unknown distributions, i.e.
     - Account for the risk that the data we have is not representative of absolute peaks

Adjustments in the proposals

- In RC25 and RC37, some adjustment for variability is made by using LSG to select top TIs
- RC 37 – No direct adjustment made
- Original RC 25 – Adjustment based on standard deviation of avg. annual fleet output
  - Difficult to use standard deviation at facility level
  - Punishes facilities with stable output

Theory and international experience

- Reliability value of IGFs tends to fall with IGF greater penetration
- The more volatile is demand, the less IGF volatility matters

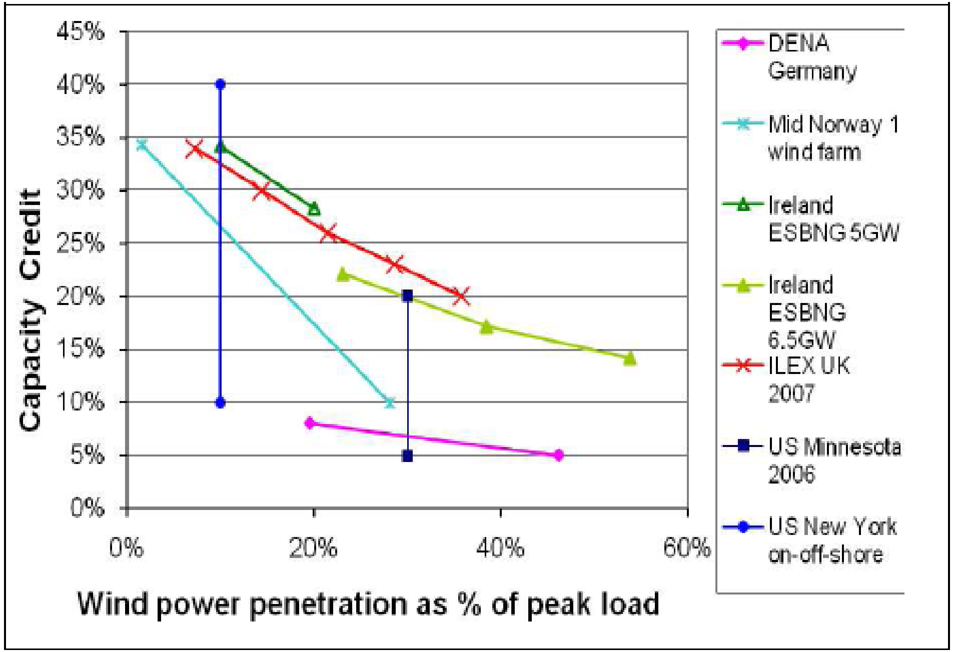


Figure 1: Capacity value of wind power: Summary of studies (Source: Keane et al. 2011)

Adjustment for additional variability

- For reasonably low levels of penetration of IGF, a useful approximation:

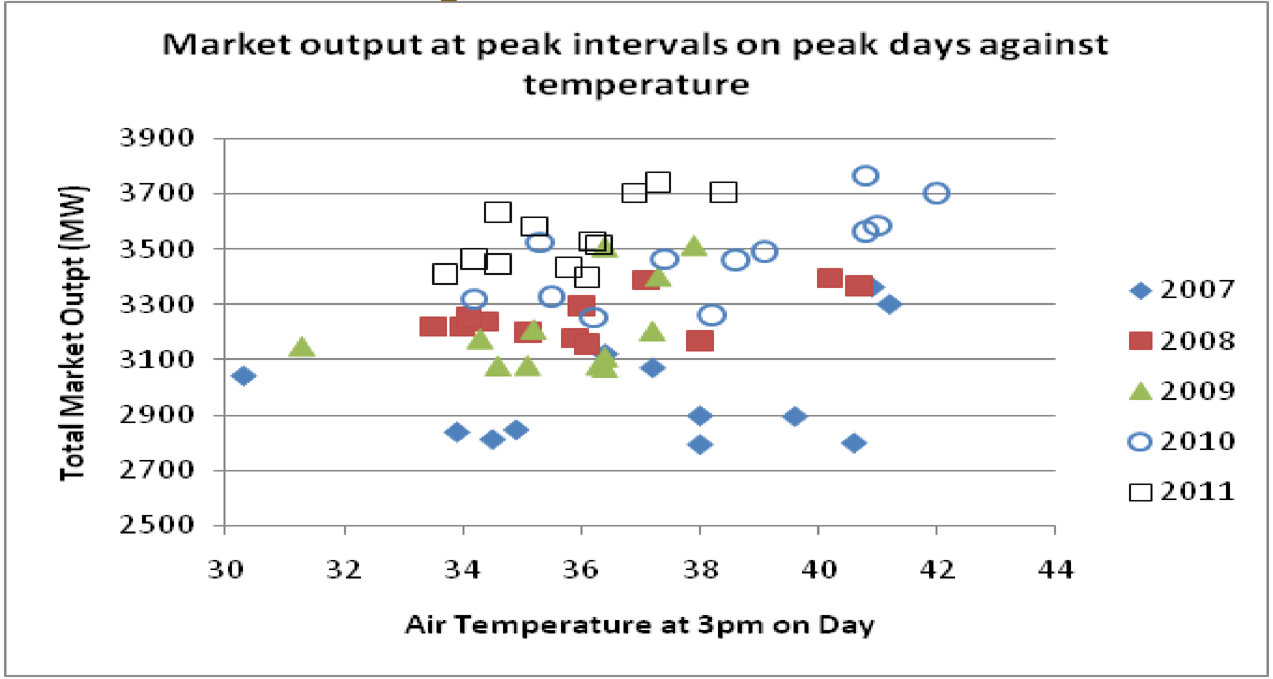
  Value ≈ *Average peak output – K* x *variance of IGF peak output*

- Variance is the standard deviation squared
- K is a constant determined by system characteristics
  - Some statistical approaches to estimating K
  - Based on international benchmarks K ≈ $0.003\ MW^{-1}$
  - But choice of *K* becomes minor compared to uncertainty issue

Unknown distribution

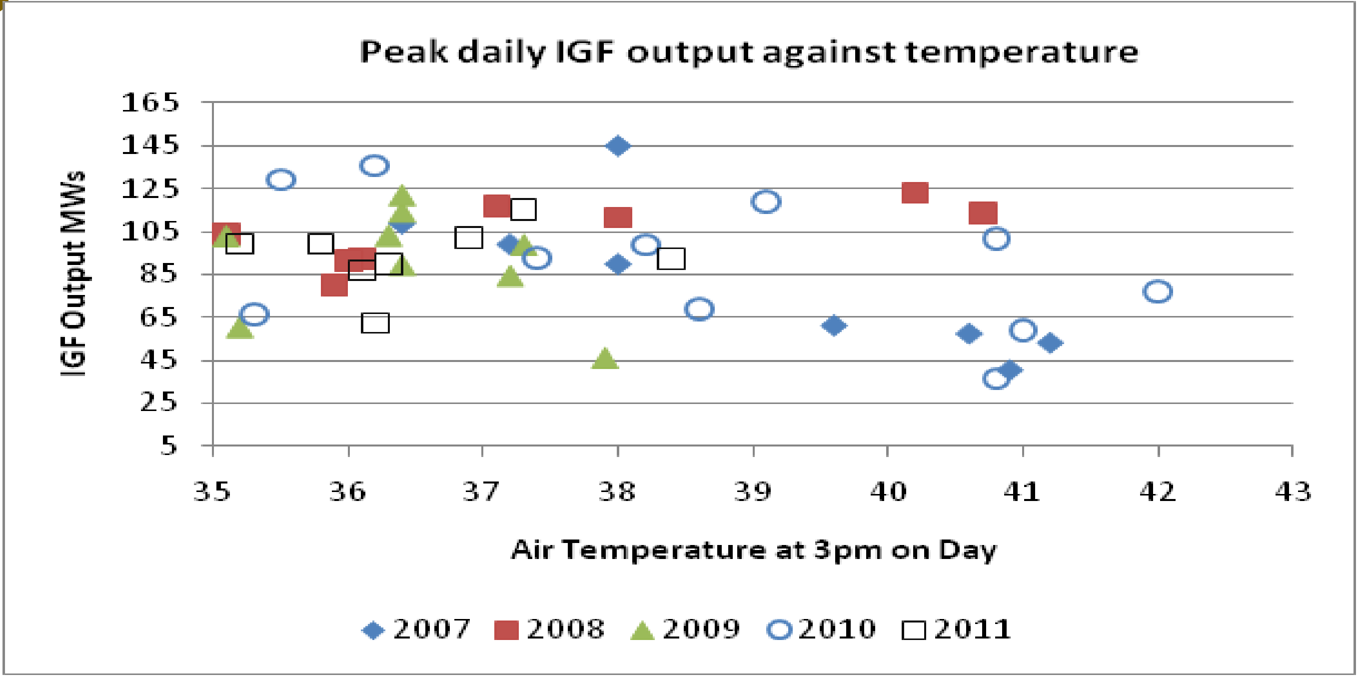
- Risk of a combined event
  - That is, events that affect both demand and output
  - We have limited data to test this.
- Texas example
  - Cold snap: Caused high demand and power outages
- Concern for the SWIS e.g.
  - Very high temperatures coincide with low wind and very high demand

Very high demand is on highest temperature days



See report for notes to the figure

But peak IGF output is lower on these days



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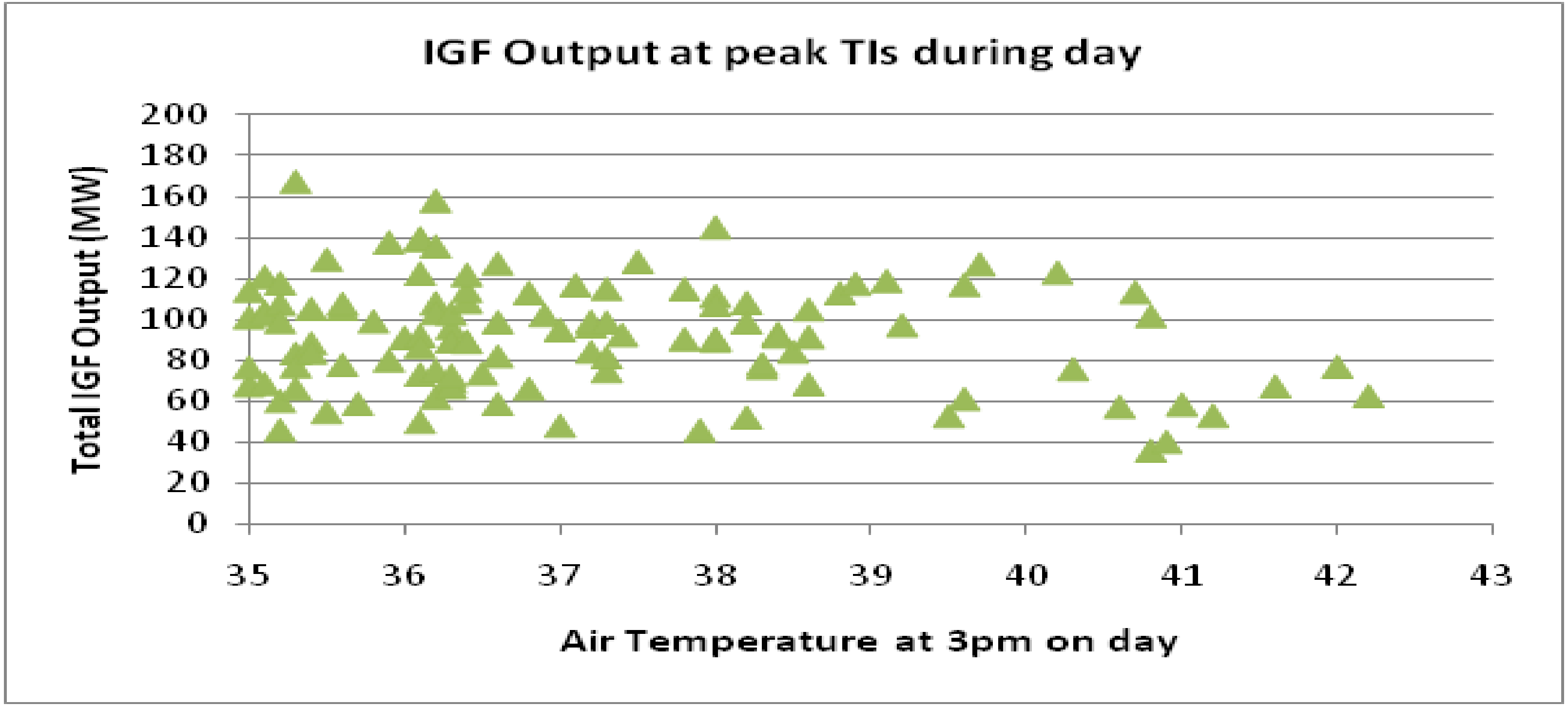

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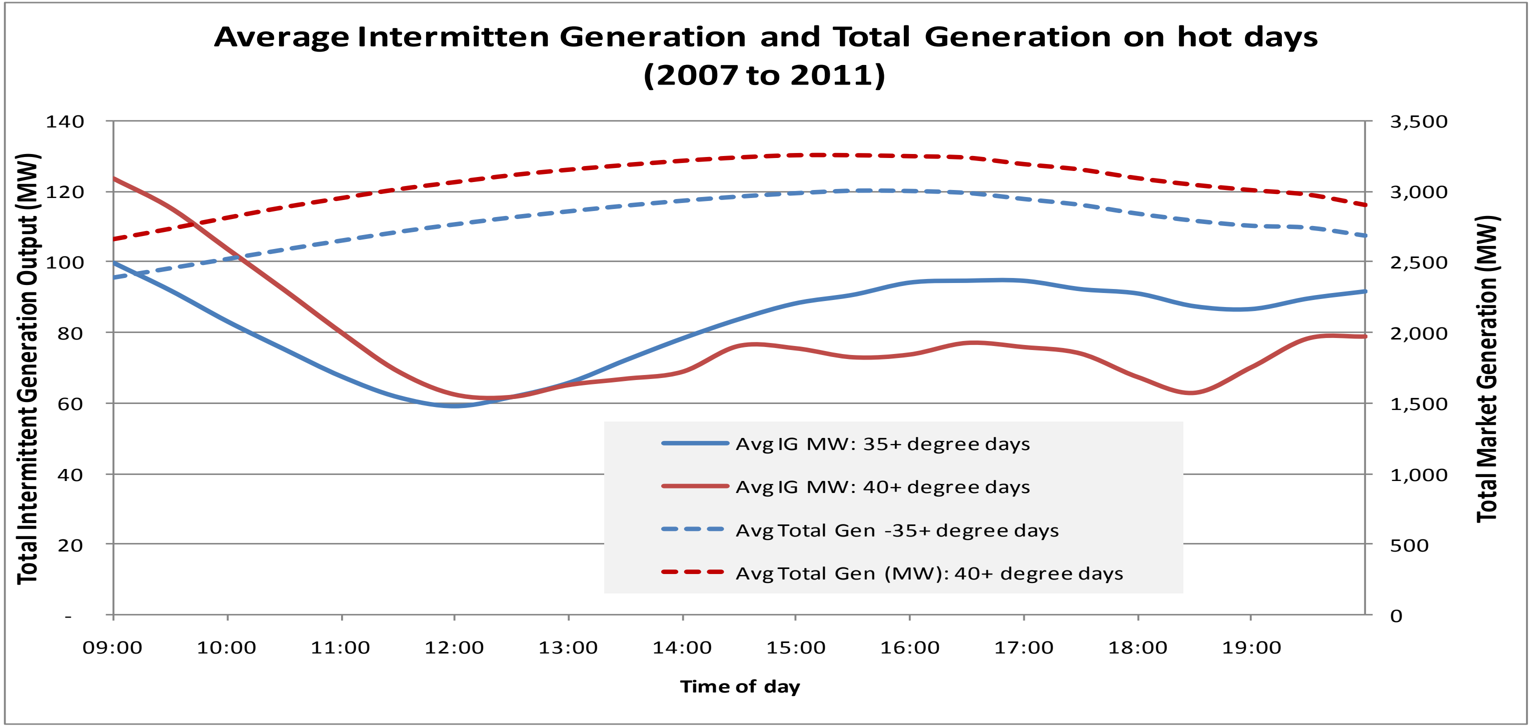
IGF output on very hot days



Contact author for further information on this figure

Making the adjustment for unknown distribution risk

- No recognised approach
- Criteria
  - Don’t penalise stable producers
  - Scalable – double the plant, double the adjustment
  - Keep it simple
- Recommended
  - Adjust in proportion to *variance* but scale down for size
  - Choose starting parameter such that overall result consistent with fleet output at extreme peaks

Recommended formula

Capacity credits = *1. Average facility output during Top 12 TIs drawn from separate days over 5 years* ***Less*** *2. **G** x variance of facility output during peaks*

Where

G = K + U reflects both *known variability* and *uncertainty*

K is initially set at $K = 0.003$ *per* MW^{-1}.

U is initially set at U=0.635/(avg IGF output *during peaks) per* MW^{-1}

Average and variance determined over the same peak TIs

Results

	Capacity Credits				As % of nameplate capacity			
Generator	**Current**	**Original RC 25**	**RC 37**	**New**	**Current**	**Original RC 25**	**RC 37**	**New**
Wind farms - Sum	**75.5**	29.5	67.1	**48.9**	**39%**	15%	35%	**25%**
- Minimum value					31%	9%	25%	12%
- Maximum value					43%	18%	38%	39%
Land fill gas – Sum	**15.6**	6.8	15.1	**14.1**	**67%**	29%	64%	**60%**
- Minimum value					34%	13%	30%	31%
- Maximum value					85%	40%	88%	82%
Sum of all	**91.1**	**36.3**	**82.2**	**63.0**	**42%**	**17%**	**38%**	**29%**

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Other considerations

- Load for Scheduled Generation (LSG) for selecting TIs
  - Benefits: Select TIs when marginal value of capacity is greatest
  - Has implications for adjustments – provides some automatic adjustment for variability in output
- Correlation between IGFs
  - Ideally formula should reflect correlation of IGF output
  - E.g. Greater value for more diverse offering
  - Can be achieved but adds complexity
- Potential weighting of TIs

The AEMO's approach

- More conservative: based on 85% PoE of output
- The AEMO does not run a capacity market.
  - Simplified approach is taken.
  - The capacity valuations are solely used for overall supply-demand planning.
  - Financial consequences and are not a material consideration in investment decisions.
- The nature of the NEM wind-farms is that their output is not closely aligned with peak times.

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Transition

- Two options for transition identified
  1. Based on averaging between current and future
  2. Based on modifying the adjustment to the average over time (the parameters to *G*)
- Recommended #2
  - Transition based on main change in approach
  - Simpler implementation
- Also: 3 year transition using straight line

Financial results

Generator	Capacity Credits as % of nameplate		Value of credits ($000s) based on Reserve Capacity Price 1/10/12 – 1/10/13 =$186,001				Change $(000)s
	Current	Proposed Final	Current Methodology	Transition Year 1	Transition Year 2	Transition Year3	Current to Final
Wind farms - Sum	**39%**	**25%**	**14,041**	**11,149**	**10,119**	**9,090**	**(4,951)**
- Minimum value	31%	12%					
- Maximum value	43%	39%					
Land fill gas – Sum	**67%**	**60%**	**2,910**	**2,716**	**2,674**	**2,631**	**(278)**
- Minimum value	34%	31%					
- Maximum value	85%	82%					
Sum of individuals	**42%**	**29%**	**16,951**	**13,865**	**12,793**	**11,722**	**(5,229)**

Review in 3 years recommended

Some recommended issues for consideration

- Further investigation into IGF output at extremes
- How TIs are selected for analysis
- Correlation between output of IGFs
- Implications of growing IGF penetration

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Thank You

Effect of LSG - Example

Period	**a. Peak MG**	***b. IGF output***	**LSG (=a – b)**	
1	**2,100**	***100***	2,000	Old peak period
2	2,080	***50***	**2,030**	New peak period
Reduction in peak = 2,100 – 2,030 = **70.**				

Fleet IGF output at peak LSG ≤ Reduction in peak to be met by scheduled generation (i.e. Peak MG minus Peak LSG) ≤ Fleet IGF output at peak MG