I-SEM CRM

Proposed De-rating Factor and Capacity Requirement Methodology

Industry Workshop

Dundalk 29/09/2016

EIRGRID SONI

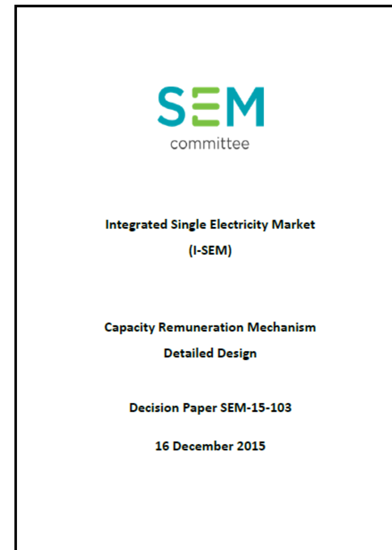
Outline

- Key SEM Committee decisions and methodology drivers
- Description of methodology
- Overview of indicative results
- Questions

Relevant SEM Committee Decisions

The following are the main SEM Committee decisions that have driven the methodology approach:

- TSOs to lead development of analytical methods
- Use a range of demand scenarios
- De-rating factors to be based on technology classes
- Centralised Marginal De-ratings
- De-rated Capacity Requirement
- Least-worst regrets analysis to be used to select demand scenario for the Capacity Requirement
- Unconstrained all-island market capacity requirement


SEM committee

Integrated Single Electricity Market
(I-SEM)

Capacity Remuneration Mechanism
Detailed Design

Decision Paper SEM-15-103

16 December 2015

Methodology Drivers

SEM Committee Decision: TSOs to develop analytical methods.

Outcomes:

- The TSOs have engaged with the RAs to ensure that the methodology delivers the SEM Committee decisions

Methodology Drivers

SEM Committee Decision: A range of demand scenarios should be used.

Outcomes:

- This requires a number of forecasts of market peak demand and energy requirements for the relevant capacity year
  - These are based on the forecasts used for the Generation Capacity Statement
  - For the current analysis they are coupled with a number historical annual profiles to give a range of demand scenarios

Methodology Drivers

SEM Committee Decision: De-rating Factors to be based on technology categories

Outcomes:

- Both existing and potential new units have to be divided into technology categories
- Based on analysis and discussion with the RAs we have created a set of broad technology categories

Methodology Drivers

SEM Committee Decision: Marginal De-rating Factors

Outcomes:

- The de-rating factors are determined by calculating the unit's marginal benefit to system adequacy and this takes account of the unit's size

Methodology Drivers

SEM Committee Decision: De-rated Capacity Requirement

Outcomes:

- The capacity requirement is given in MW of de-rated capacity and not real/nameplate capacity

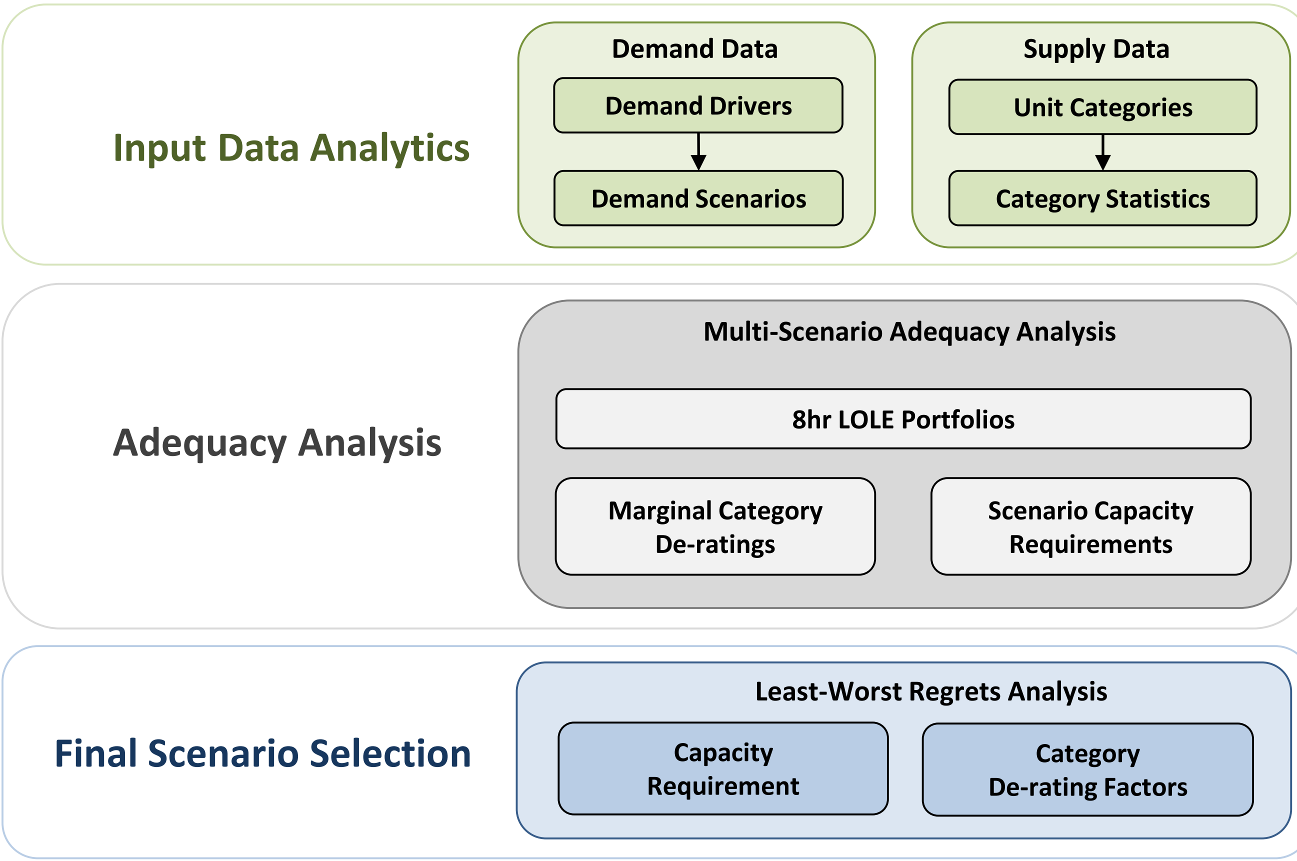
Methodology Drivers

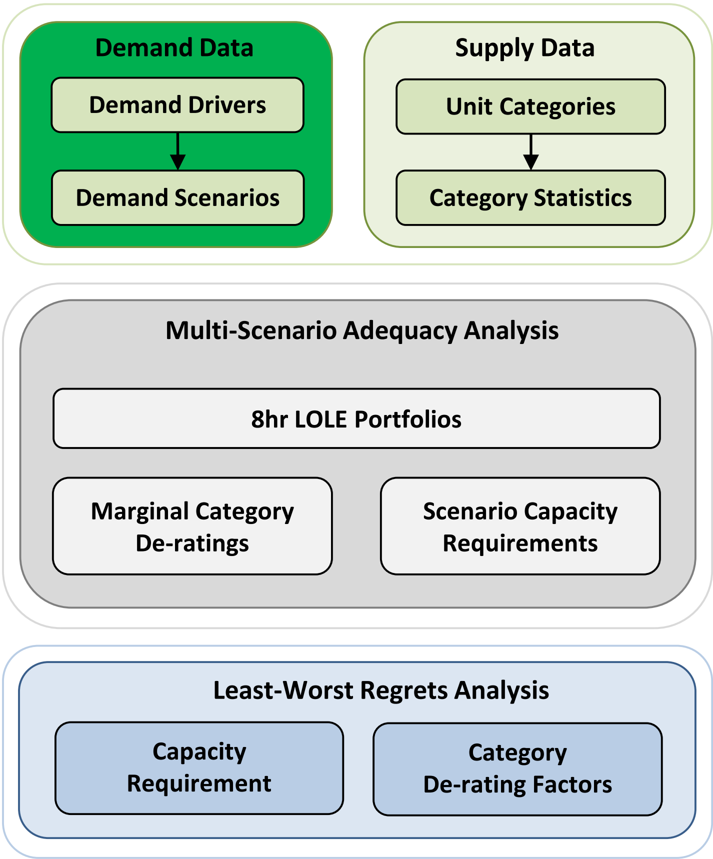
SEM Committee Decision: Least-worst regrets analysis to be used to select the optimal demand scenario that sets the capacity requirement

Outcomes:

- The least worst regrets analysis requires a capacity requirement and a measure of Expected Unserved Energy (EUE) for each demand scenario
- These values are combined with Net-CONE and VoLL to perform the Least-Worst Regrets Analysis

Methodology Overview



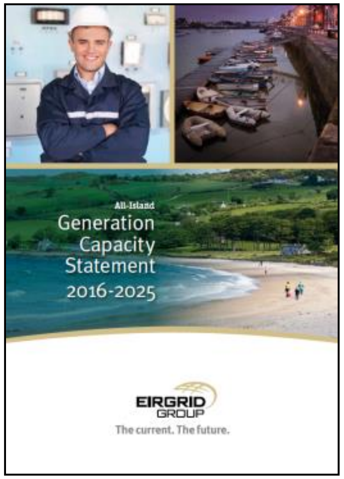


Demand Data

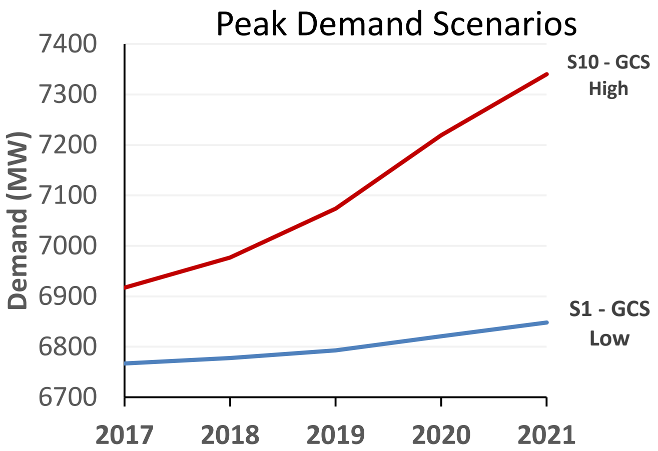
Developing the demand scenarios

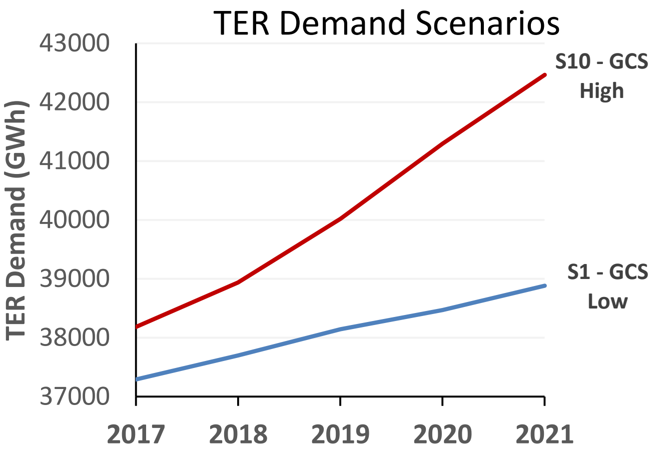
Demand Forecasts

- The current Generation Capacity Statement was used to create the demand forecasts for this analysis
- Forecasts in the Generation Capacity Statement are derived using analysis of historic relationships between demand and demand drivers, emerging trends and 10-year driver projections



CRM Demand Forecasts





- The charts above give the GCS low and high forecasts for demand Peak and Total Energy Requirement (TER) demand
- The wider spread each year reflects increased uncertainty

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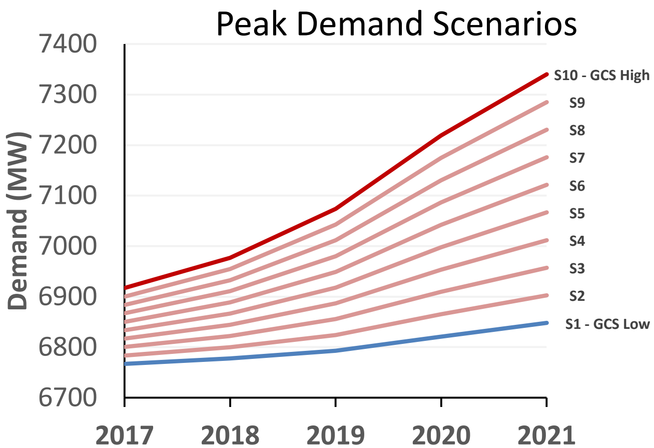
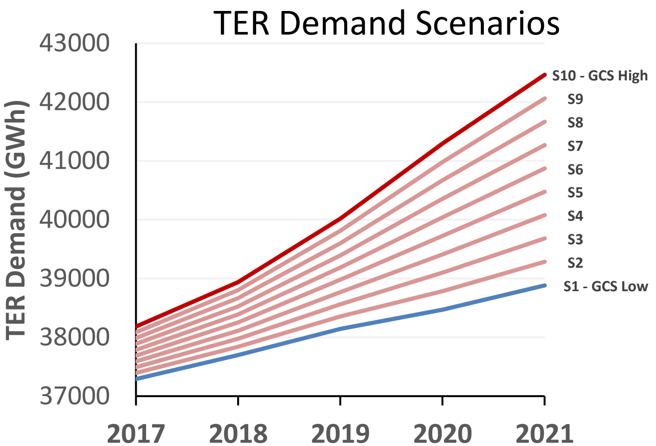
CRM Demand Forecasts

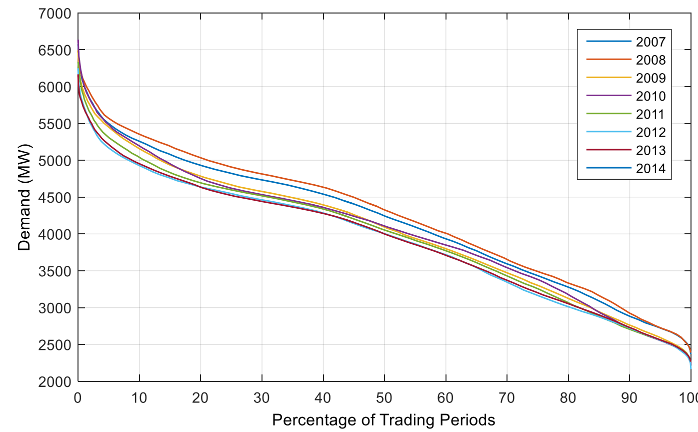


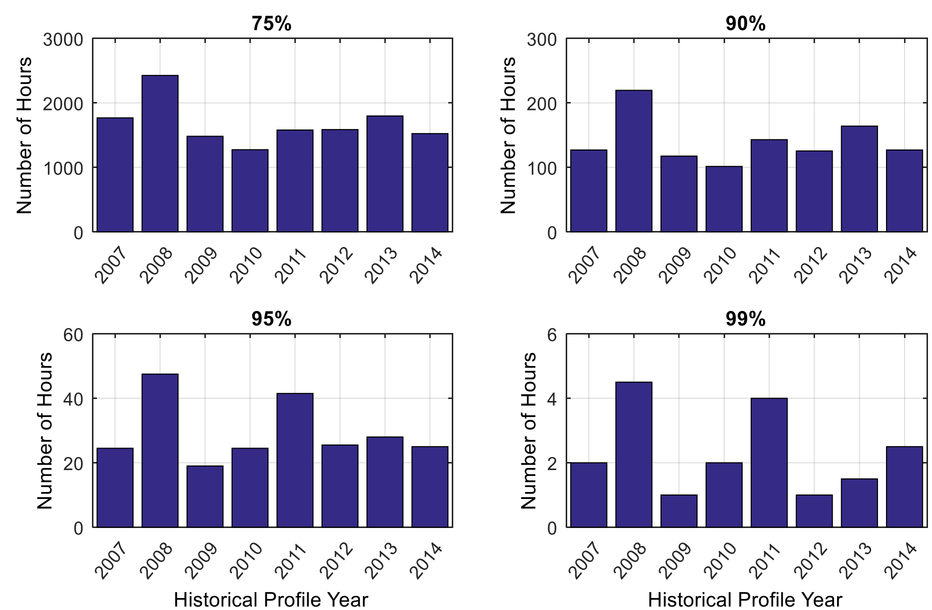


- The charts above give the GCS low and high forecasts for demand Peak and Total Energy Requirement (TER) demand
- The wider spread each year reflects increased uncertainty
- The peak and TER GCS range are divided into a number of demand forecasts

Why use multiple demand profiles?

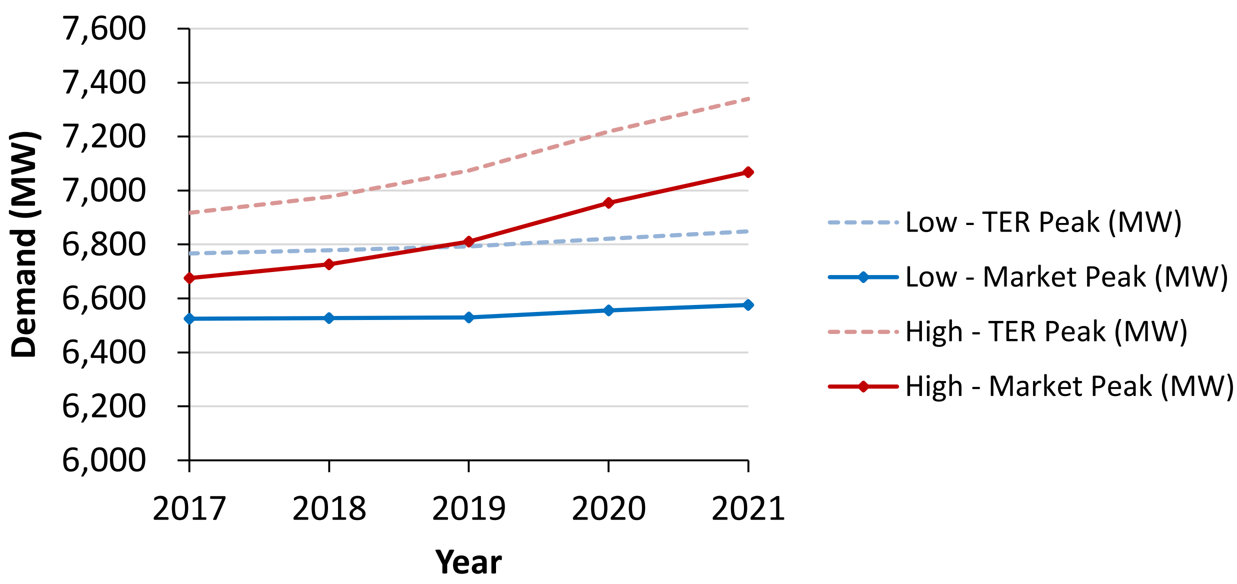
- The choice of profile can influence the capacity requirement
- Charts give load duration curves and the number of hours in the year that the demand is >= 75%, 90%, 95% and 99% of the peak demand
- The number of hours close to the peak influences the capacity required to meet the LOLE standard





Adjustment for Non-market Small-scale Generation

- The peak and energy demand forecasts from the GCS are adjusted to account for non-market small-scale generation to produce the market forecast that is used in the adequacy calculations
- The graph illustrates the adjustment for the high and low demand forecasts



Treatment of Reserve Requirement

- Reserve to cover the largest infeed is added to the load profiles for each of the forecasts used in the Capacity Requirement calculations.
- This is in line with the simulations used for the basecase in the current ENTSO-E MAF report and the treatment of reserve in the GB capacity requirement calculation
- For the purpose of this analysis the operating reserve requirement is set to cover the largest firm generator infeed (currently 444 MW)
- Not in current CPM calculation and RAs have requested stakeholders views on the inclusion of reserve

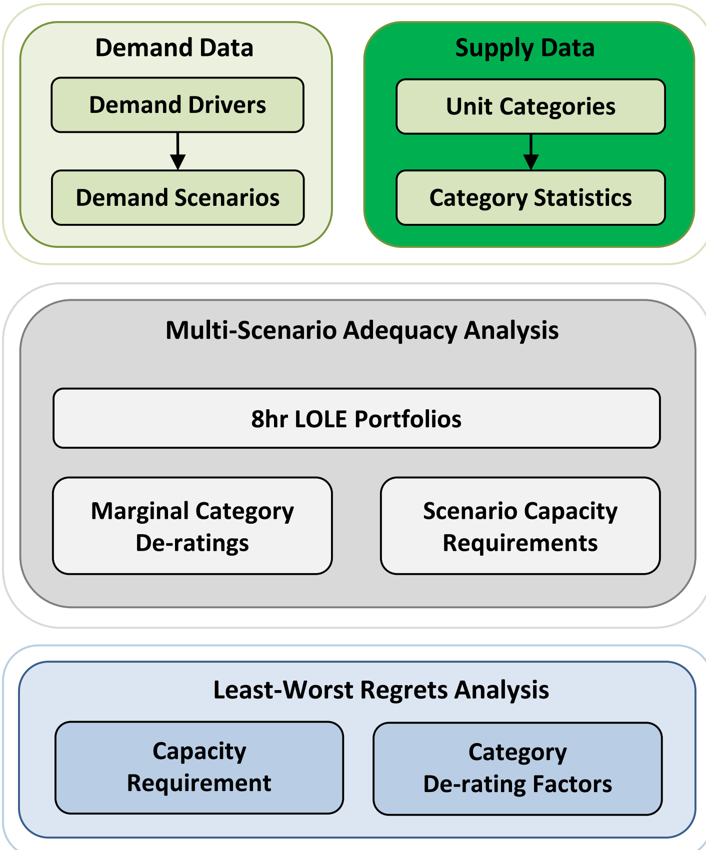
Demand Data

Demand Forecasts combined with Historical Demand Profiles

− Non-market Demand

\+ Reserve Requirement

→ Demand Scenarios



Supply Data

Calculating category outage statistics and setting up the capacity portfolio

Availability Statistics - Categories

- For the purpose of calculating availability statistics and de-rating factors units are divided into a number of broad technology categories
  - This choice was based on analysis of the system portfolio including 5-year outage data for each unit (extracted from EDIL) and discussion with the RAs
- This delivers on the SEM Committee decision and leads to more stable statistics from year-to-year
  - Both at unit and system-wide level

Availability Statistics - Categories

On discussion with the RAs the following categories have been selected:

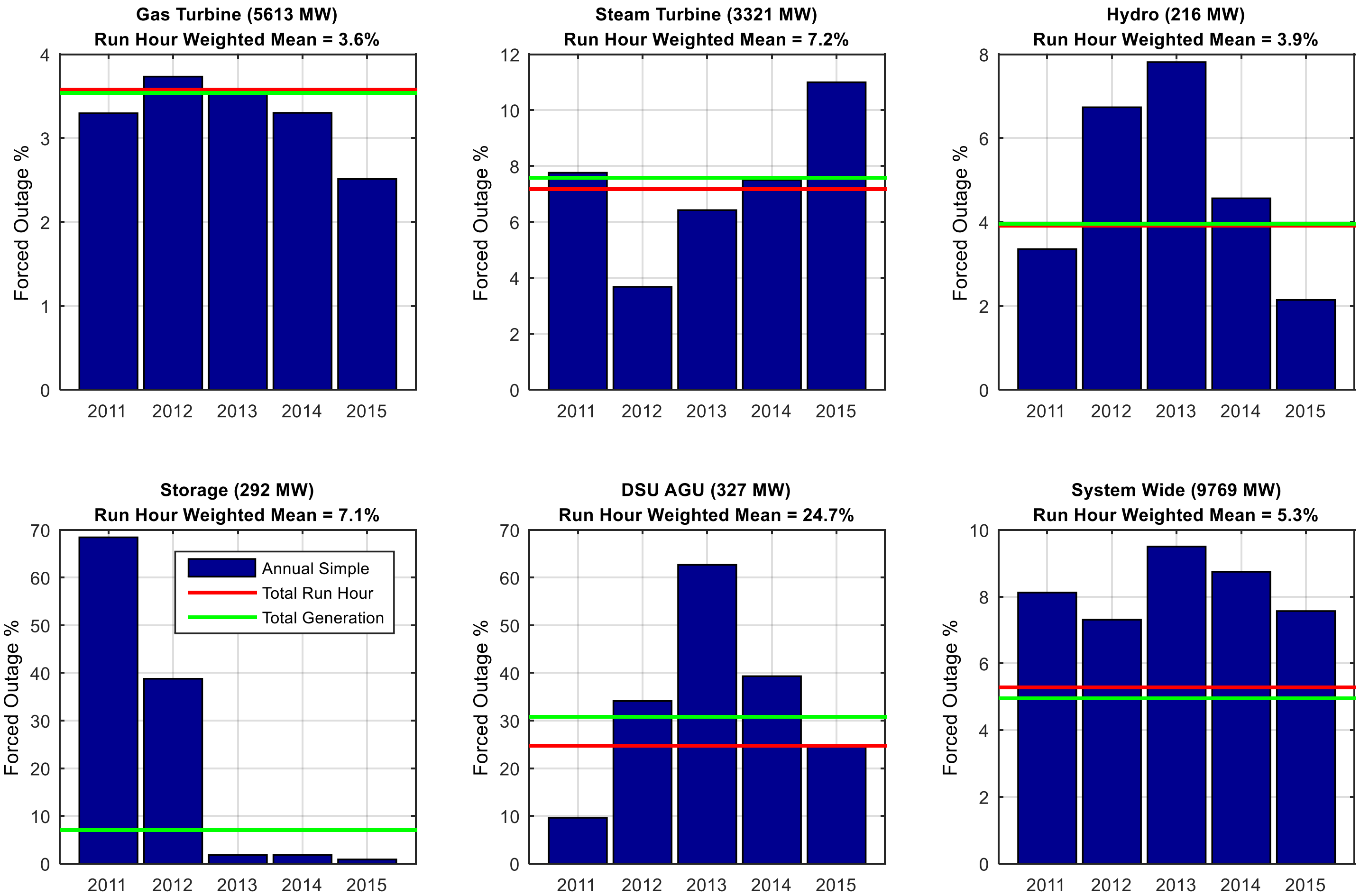
Technology Category	Unit types included
DSU AGU	Demand side units (including aggregated units)
Gas Turbine	CCGT, Gas and Distillate OCGT, Large CHP
Hydro	Hydro
Steam Turbine	Oil, Coal, Peat
Storage	Pumped Storage*
Wind	Wind
System Wide	All of the above.

- In table 2 of the consultation document Distillate is mistakenly listed in the Steam Turbine category. It should be in the Gas Turbine category. The analysis has included it in the Gas Turbine category.
- In the future this could include compressed air, battery and other grid powered storage technologies.

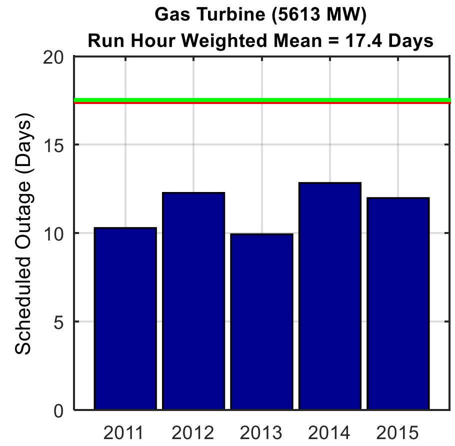
Availability Statistics - Weightings

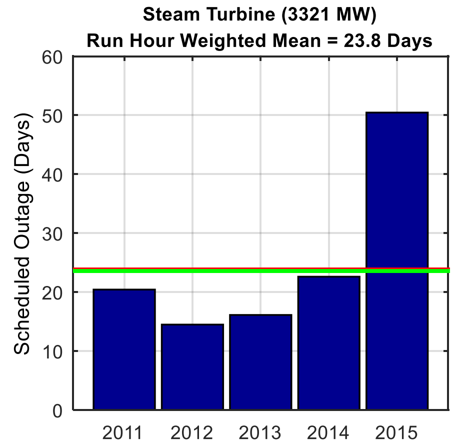
- A run-hour weighting is applied to calculate the outage statistics
  - Would like to reflect that availability statistics are less reliable for units with low run-hours
- The alternatives of a simple average, capacity weighted average and generation weighted average were investigated
- A run-hour weighting was chosen as it did not bias the results towards larger units

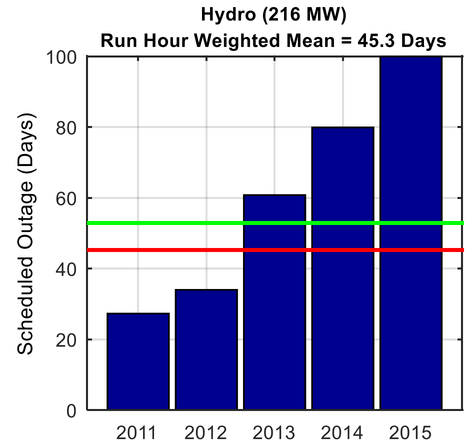
Forced Outages

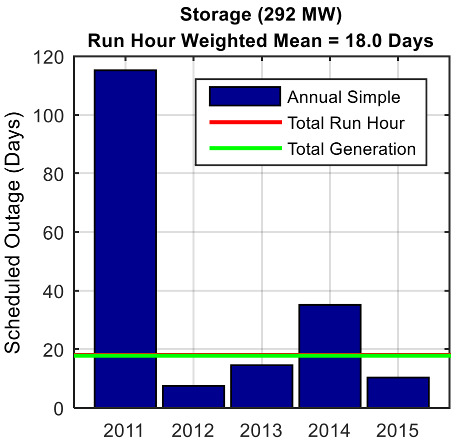


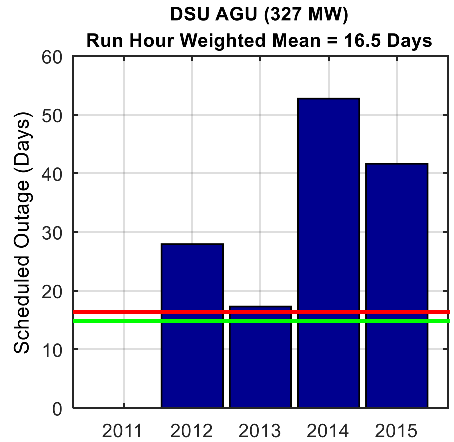
Scheduled Outages

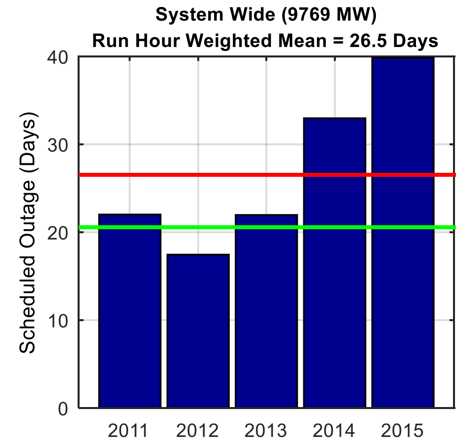




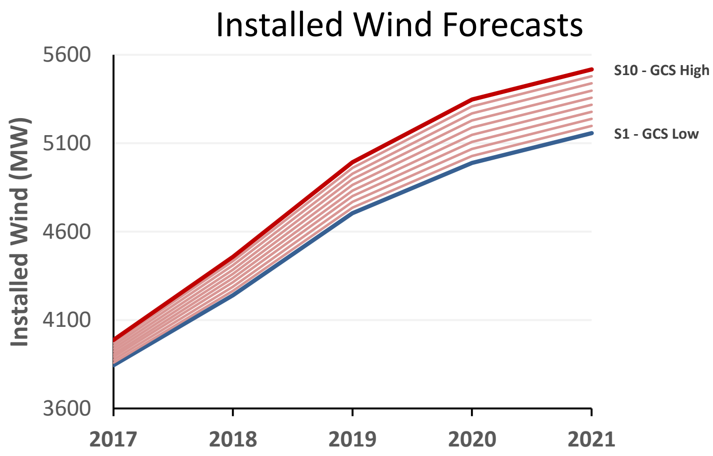


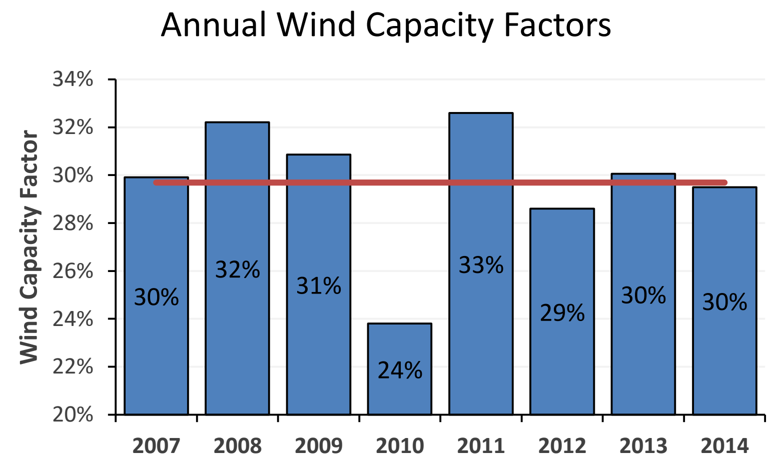






Wind Data





- Left graph gives the wind build-out forecasts which coincide with those presented in the GCS
- The wind capacity factors for 2007 – 2014 are given on the right
- A number of wind profile years are being used to derive a de-rating factor for wind. These are paired with the same demand year when calculating de-rating factors

New Unit - Existing Category

- New capacity that conforms to one of the existing technology categories set out in this methodology takes on the values associated with that technology category

- The approach for determining marginal de-rating factors can determine de-rating factors for a unit of any size for a given technology category.

- This provides a default de-rating factor for any new unit that falls in the same technology category, and no data is required for such a unit.

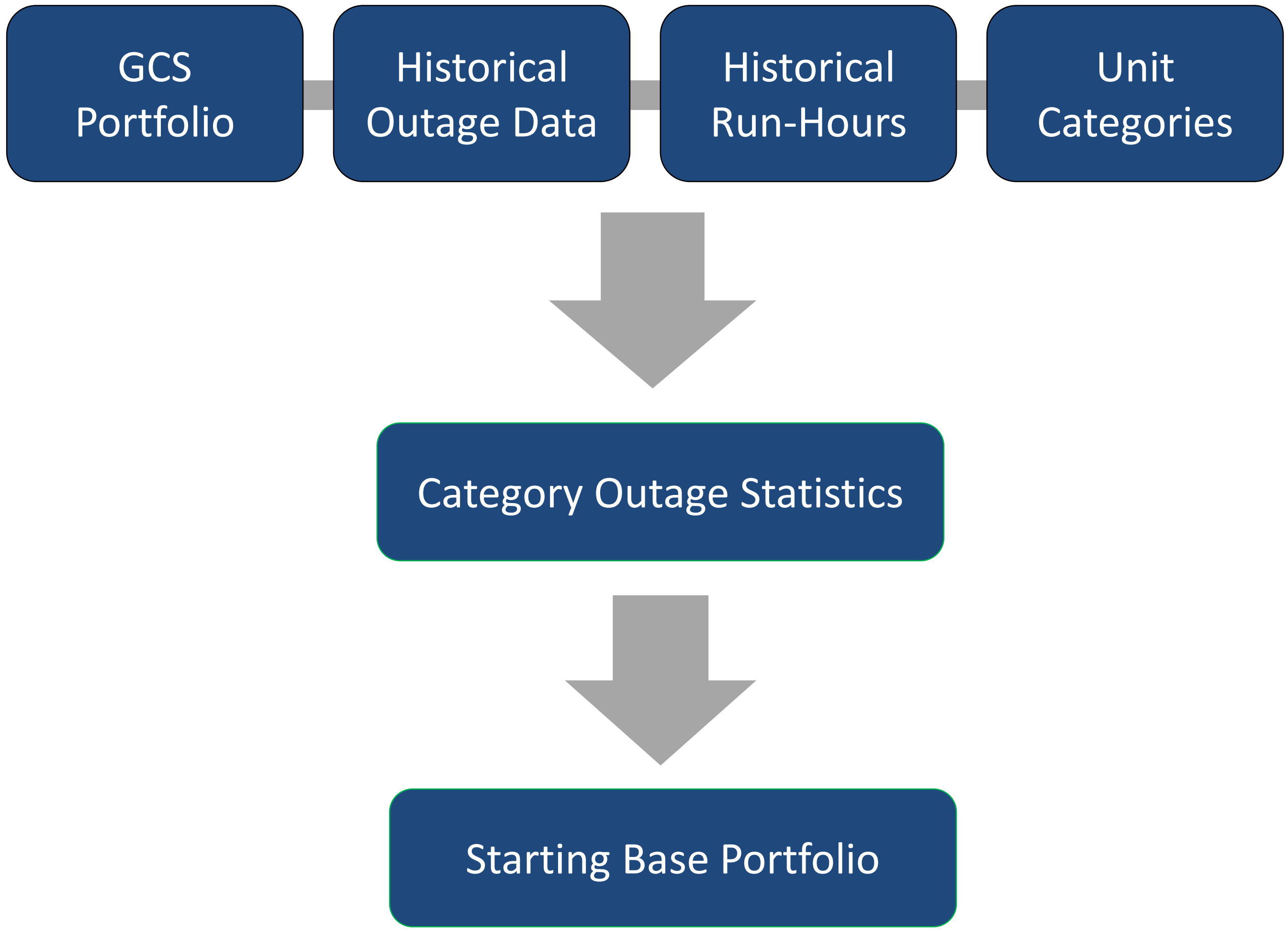
New Units - New Category

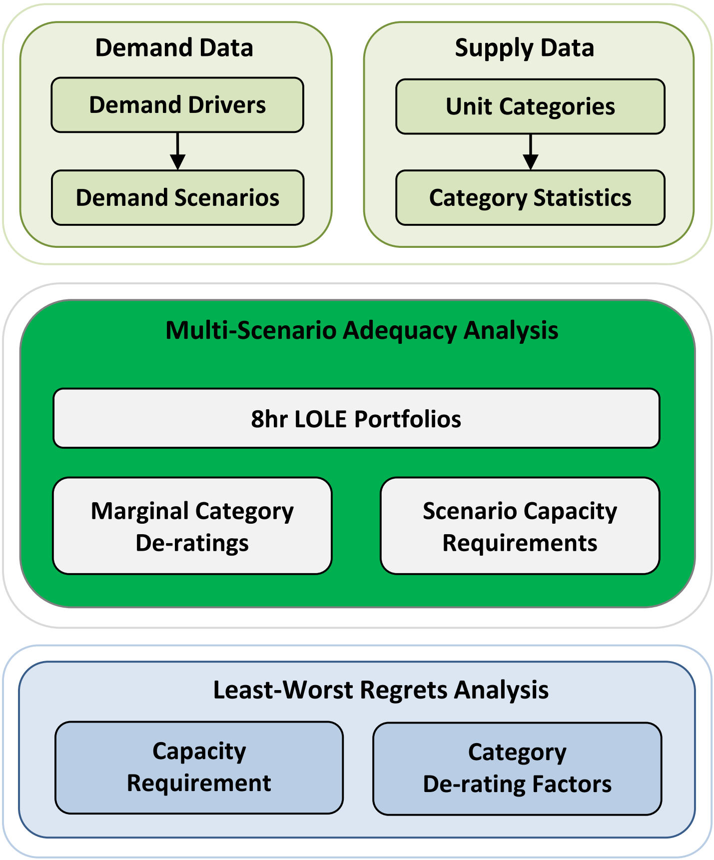
- New capacity that does not conform to the existing categories will be given values associated with the system average outage rates.
- If the new unit accepts a multiple-year reliability option contract the de-rating factor could be increased over time as actual performance data becomes available, but it cannot be decreased.
  - Their reliability option quantity would only increase if they traded further in the primary or secondary auctions.
- Therefore, it is important to have a degree of conservatism in setting the initial de-rating factors.

New Units – Variable Resources

- Based on an hourly variable generation profile using the relevant annual 1 MW normalized resource profile (e.g. solar)
  - i.e. an annual profile of values between 0 and 1 is applied to the installed capacity of that variable resource
- These profiles would be incorporated into the analysis using the same methodology as is used for wind capacity.

Supply Data


GCS Portfolio
Historical Outage Data
Historical Run-Hours
Unit Categories
Category Outage Statistics
Starting Base Portfolio

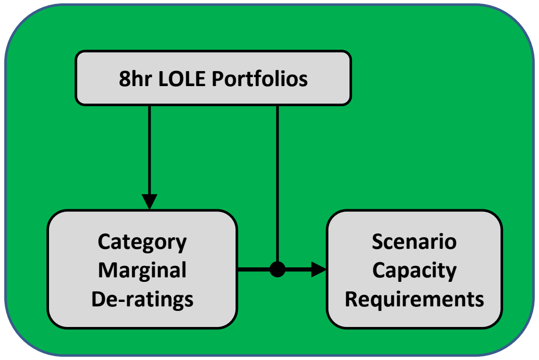


Multi-Scenario Adequacy Analysis

Calculate marginal de-rating factors and capacity requirements for each demand scenario

Multi-Scenario Adequacy Analysis

- The Multi-Scenario Adequacy Analysis module calculates the marginal de-rating factors and capacity requirements for a range of demand scenarios and capacity provider portfolios



- This is required to create inputs for the Least-Worst Regrets Analysis

8hr LOLE Portfolios

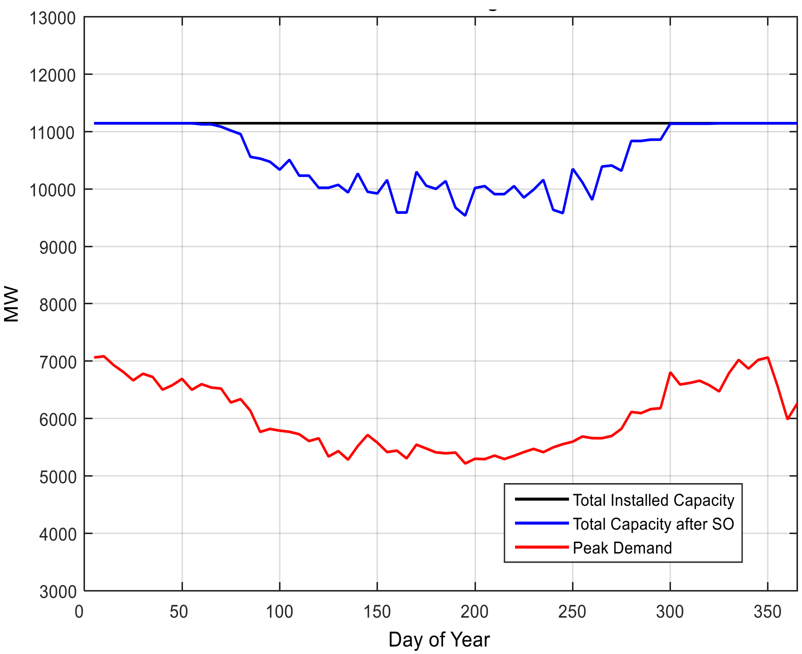
- A number of 8hr LOLE portfolios are created for each demand scenario
- The portfolios are created as they are used to represent the capacity that clears the auction
- The 8hr LOLE portfolio is constructed by adding/removing units from the starting base portfolio until the adequacy standard is reached
- These 8hr LOLE portfolios are used as the reference portfolio on which the marginal de-rating factors and scenario capacity requirements are calculated

Calculating Loss of Load Probability

- For any given hour the Loss of Load Probability is a function of the demand in that hour, the generation portfolio and the forced outage rate
- The generation portfolio in that hour consists of all units that are not on scheduled outage
  - The relevant units' capacities also are adjusted for any ambient outages
- The demand is taken from the demand scenario data
- The LOLP is calculated for all hours of the year and then summed to give the LOLE

Scheduling Scheduled Outages

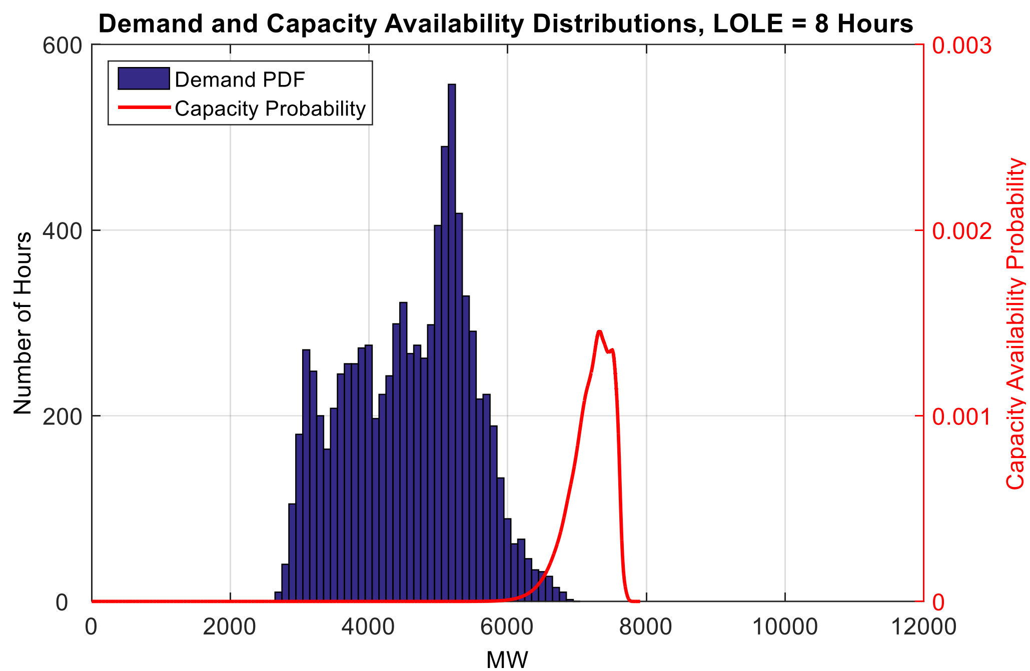
- The chart gives an illustrative example of scheduled outages for one scenario
- The algorithm schedule each outage in order from largest to smallest of outage (*unit size* x *outage duration*)
- Outages are scheduled in the period that matches the outage season
- Scheduled outages have a minor impact on de-rating factors but can impact on the capacity requirement



Illustrative Example

8Hr LOLE Portfolio Generation

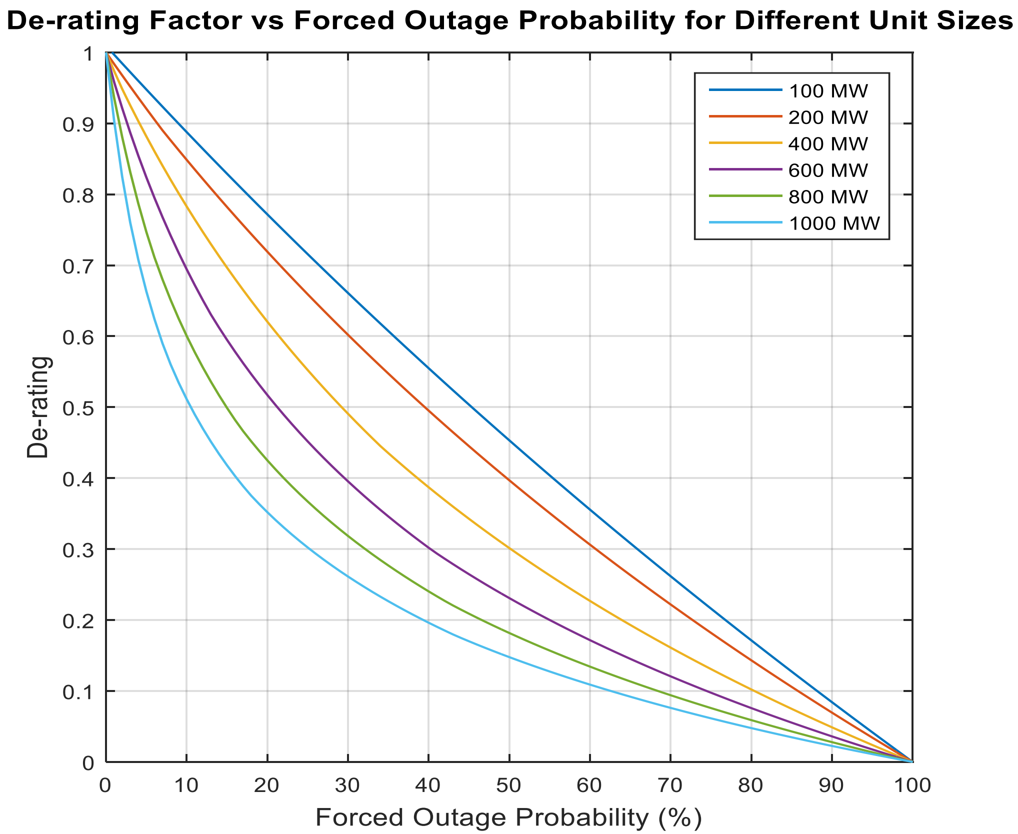
- The graph shows the probability density function of an annual demand (blue)
- The graph also includes the Available Capacity probability from an 8 hour portfolio (green line)
- The intersection of the demand and capacity distributions gives the 8 hour LOLE



Illustrative Example

Category Marginal De-ratings

- Marginal de-rating factors reflect the marginal benefit of a unit to system adequacy
- Using this approach, for a given Forced Outage rate, large units will have lower de-rating factors than small units
- This effect is illustrated in the figure on the right



Illustrative Example

Category Marginal De-ratings

- The marginal de-rating factors for each unit (category/size) are calculated using:

$$Derating = \frac{Surplus_{with} - Surplus_{without}}{Unit\ Size}$$

- For each of the 8hr portfolios and demand scenarios described above marginal de-ratings factors are calculated for each technology category and size class

Calculating Wind De-rating Factor

- Wind is treated in a similar manner to other technologies

  i.e. its de-rating factor is calculated by dividing the change in surplus due to the addition of wind by the total installed capacity of wind

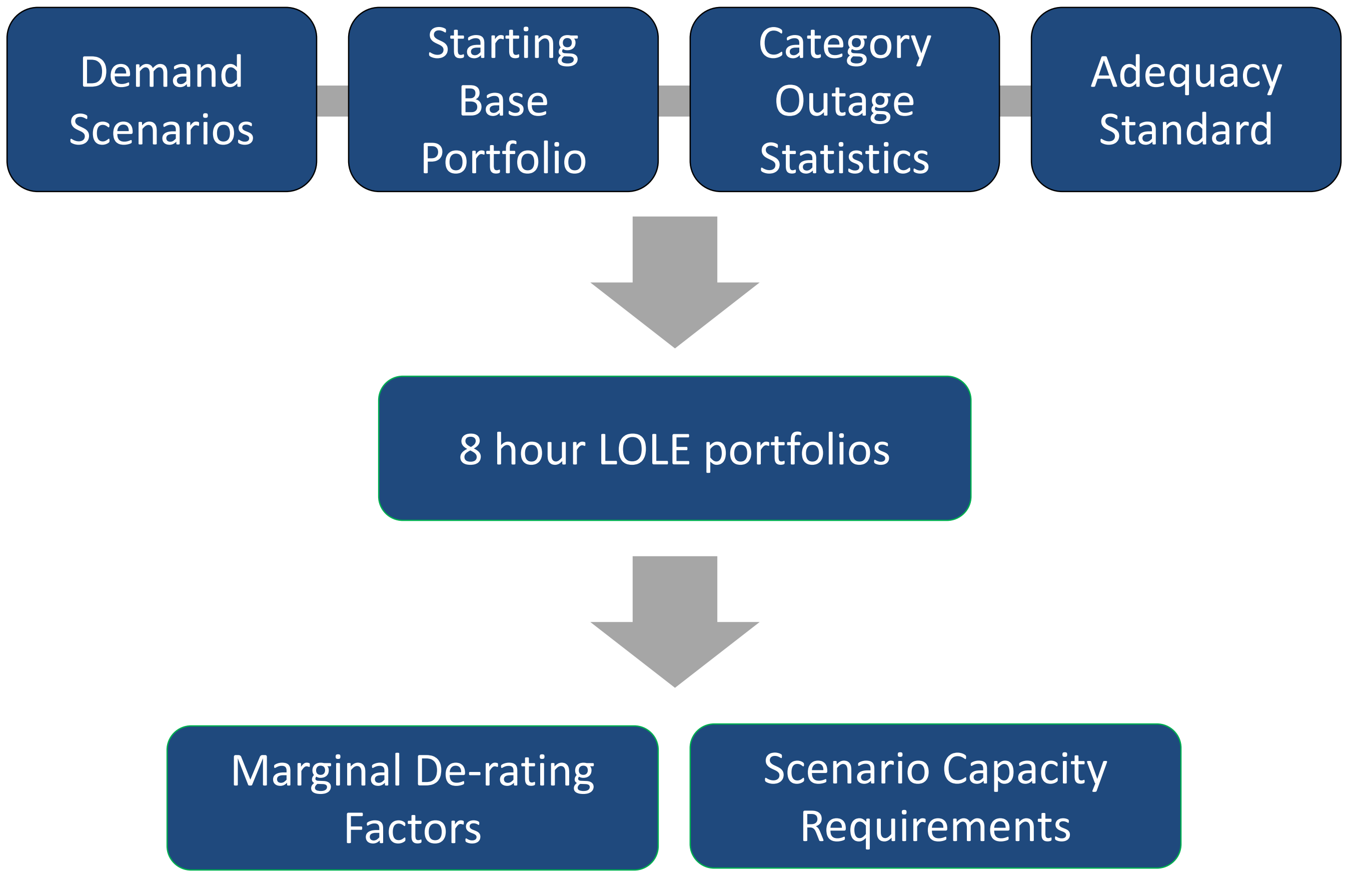
- The de-rating factors for wind are calculated for a range of wind-demand profile pairs

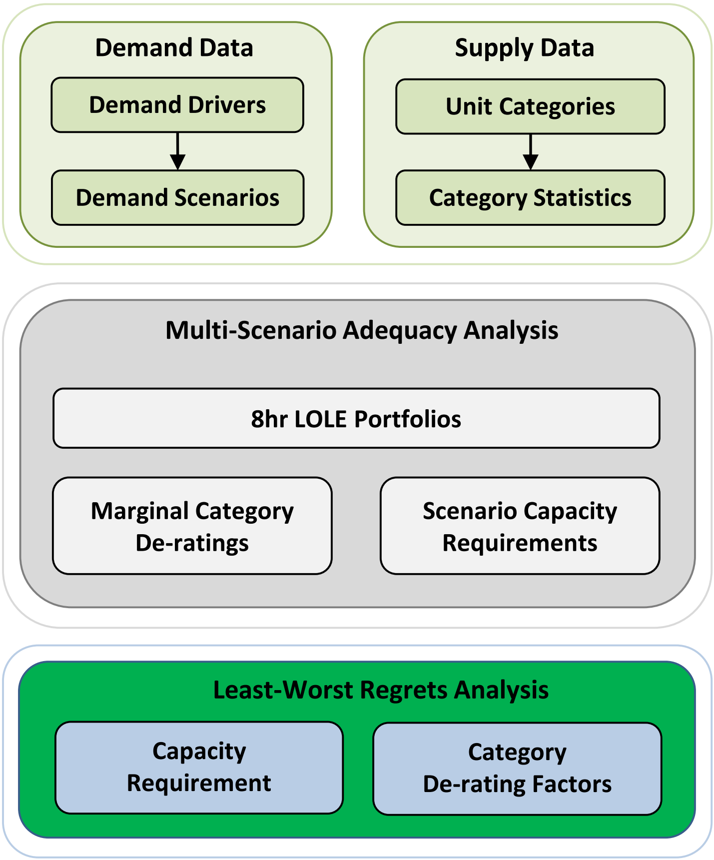
- We have recommended using the average de-rating factor from these profile pairs as the de-rating factor that should be applied to wind

Scenario Capacity Requirements

- To calculate the capacity requirements for each demand scenario:
  - For each 8 hour LOLE portfolio multiply the capacity of the units in the 8 hour LOLE portfolio by their associated de-rating factors
  - Then sum this de-rated capacity to give de-rated capacity of that portfolio
- We recommend using the largest resulting de-rated portfolio capacity requirement to set the capacity requirement for that demand scenario
  - Helps to ensure that the capacity requirement is robust against a number of possible auction outcomes

Scenario Capacity Requirements and De-rating Factors





Least-Worst Regrets Analysis

Selecting the optimal demand scenario for the auction Capacity Requirement

Least-Worst Regrets Analysis

Consider the case where Demand Scenario B has been used to set the capacity requirement:

- **What happens if it is Demand Scenario A, C, D, etc. that actually occurs?**
  - If the demand scenario that occurs has a higher demand/capacity requirement it would result in an increase in expected unserved energy
  - If the demand scenario that occurs has a lower demand/capacity requirement it would mean that we would have procured more capacity than was required
- Any increase in expected unserved energy is priced at VoLL and excess capacity is priced at Net-CONE
- To simulate these potential outcomes, the methodology assesses the capacity adequate reference portfolios for each demand scenario against all other possible demand scenarios

Least-Worst Regrets Analysis

Calculate Regret Cost 1 - Too much capacity:

- If the outturn demand is lower than that in the scenario being evaluated, using that scenario would lead to the purchase of more capacity than is required.
- This is priced at Net-CONE to give the regret cost (example given below in €millions)

Outcome Scenarios →

Input Scenarios ↓

Scenario	F1P1	F1P2	F1P3	F2P1	F2P2	F2P3	F3P1	F3P2	F3P3	F4P1	F4P2	F4P3	F5P1	F5P2	F5P3
F1P1 - 6754 MW	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0
F1P2 - 6766 MW	1	0	4	0	0	0	0	0	0	0	0	0	0	0	0
F1P3 - 6715 MW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F2P1 - 6848 MW	7	6	10	0	0	2	0	0	0	0	0	0	0	0	0
F2P2 - 6864 MW	8	7	11	1	0	3	0	0	0	0	0	0	0	0	0
F2P3 - 6826 MW	5	4	8	0	0	0	0	0	0	0	0	0	0	0	0
F3P1 - 6944 MW	14	13	17	7	6	9	0	0	2	0	0	0	0	0	0
F3P2 - 6973 MW	16	15	19	9	8	11	2	0	5	0	0	0	0	0	0
F3P3 - 6911 MW	11	11	14	5	3	6	0	0	0	0	0	0	0	0	0
F4P1 - 7065 MW	23	22	25	16	15	17	9	7	11	0	0	4	0	0	0
F4P2 - 7088 MW	24	23	27	17	16	19	10	8	13	2	0	5	0	0	0
F4P3 - 7013 MW	19	18	22	12	11	14	5	3	7	0	0	0	0	0	0
F5P1 - 7151 MW	29	28	32	22	21	24	15	13	17	6	5	10	0	0	2
F5P2 - 7196 MW	32	31	35	25	24	27	18	16	21	10	8	13	3	0	5
F5P3 - 7124 MW	27	26	30	20	19	22	13	11	16	4	3	8	0	0	0

Least-Worst Regrets Analysis

Calculate Regret Cost 2 - Too little capacity (excess EUE):

- If the outturn demand is higher than that in the scenario being evaluated, using that scenario would lead to the purchase of less capacity than is required. This, in turn would increase the MWh expected level of unserved energy.
- This is priced at VoLL to give the regret cost (example given below in €millions)

Outcome Scenarios

Input Scenarios

Scenario	F1P1	F1P2	F1P3	F2P1	F2P2	F2P3	F3P1	F3P2	F3P3	F4P1	F4P2	F4P3	F5P1	F5P2	F5P3
F1P1 - 6754 MW	0	3	0	11	15	6	28	35	20	52	64	41	88	106	72
F1P2 - 6766 MW	0	0	0	8	11	3	22	28	16	44	54	34	77	92	62
F1P3 - 6715 MW	4	7	0	17	22	11	37	45	28	66	79	52	108	129	88
F2P1 - 6848 MW	0	0	0	0	3	0	11	15	6	28	35	20	52	63	41
F2P2 - 6864 MW	0	0	0	0	0	0	8	11	3	22	28	16	44	54	34
F2P3 - 6826 MW	0	0	0	4	7	0	17	22	11	36	45	27	65	78	52
F3P1 - 6944 MW	0	0	0	0	0	0	0	2	0	11	15	6	28	35	20
F3P2 - 6973 MW	0	0	0	0	0	0	0	0	0	8	11	3	22	28	16
F3P3 - 6911 MW	0	0	0	0	0	0	4	7	0	17	22	11	36	45	28
F4P1 - 7065 MW	0	0	0	0	0	0	0	0	0	0	3	0	11	15	6
F4P2 - 7088 MW	0	0	0	0	0	0	0	0	0	0	0	0	7	11	3
F4P3 - 7013 MW	0	0	0	0	0	0	0	0	0	4	7	0	17	22	11
F5P1 - 7151 MW	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
F5P2 - 7196 MW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F5P3 - 7124 MW	0	0	0	0	0	0	0	0	0	0	0	0	4	7	0

Least-Worst Regrets Analysis

Select the Least Worst Regret:

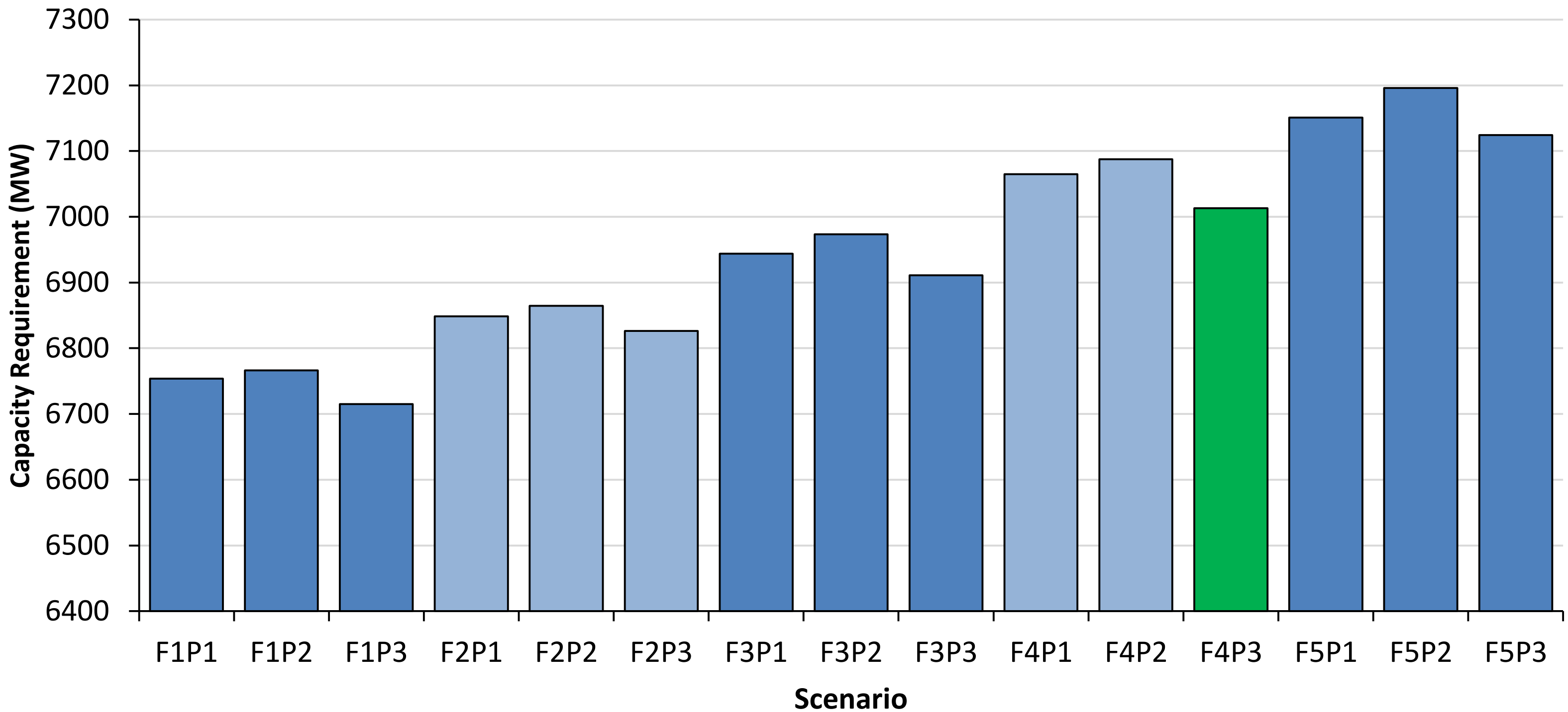
The two components of regret cost are combined into a single table, and the worst regret cost for each is determined. The scenario that has the lowest worst regret cost is selected as being the optimal scenario for the auction.

Outcome Scenarios

Input Scenarios

Scenario	F1P1	F1P2	F1P3	F2P1	F2P2	F2P3	F3P1	F3P2	F3P3	F4P1	F4P2	F4P3	F5P1	F5P2	F5P3	Max Regret	Least-Worst Regret
F1P1 - 6754 MW	0	3	3	11	15	6	28	35	20	52	64	41	88	106	72	106	
F1P2 - 6766 MW	1	0	4	8	11	3	22	28	16	44	54	34	77	92	62	92	
F1P3 - 6715 MW	4	7	0	17	22	11	37	45	28	66	79	52	108	129	88	129	
F2P1 - 6848 MW	7	6	10	0	3	2	11	15	6	28	35	20	52	63	41	63	
F2P2 - 6864 MW	8	7	11	1	0	3	8	11	3	22	28	16	44	54	34	54	
F2P3 - 6826 MW	5	4	8	4	7	0	17	22	11	36	45	27	65	78	52	78	
F3P1 - 6944 MW	14	13	17	7	6	9	0	2	2	11	15	6	28	35	20	35	
F3P2 - 6973 MW	16	15	19	9	8	11	2	0	5	8	11	3	22	28	16	28	
F3P3 - 6911 MW	11	11	14	5	3	6	4	7	0	17	22	11	36	45	28	45	
F4P1 - 7065 MW	23	22	25	16	15	17	9	7	11	0	3	4	11	15	6	25	
F4P2 - 7088 MW	24	23	27	17	16	19	10	8	13	2	0	5	7	11	3	27	
F4P3 - 7013 MW	19	18	22	12	11	14	5	3	7	4	7	0	17	22	11	22	22
F5P1 - 7151 MW	29	28	32	22	21	24	15	13	17	6	5	10	0	3	2	32	
F5P2 - 7196 MW	32	31	35	25	24	27	18	16	21	10	8	13	3	0	5	35	
F5P3 - 7124 MW	27	26	30	20	19	22	13	11	16	4	3	8	4	7	0	30	

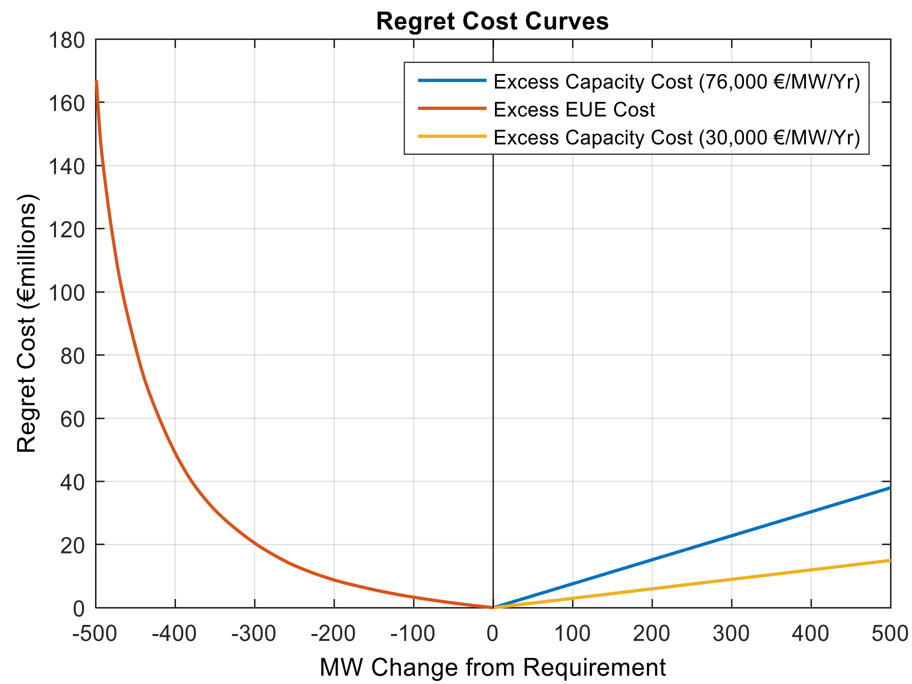
Least-Worst Regrets Analysis



- The Capacity requirement selected through the least-worst regrets analysis for the example set of scenarios is given in green above

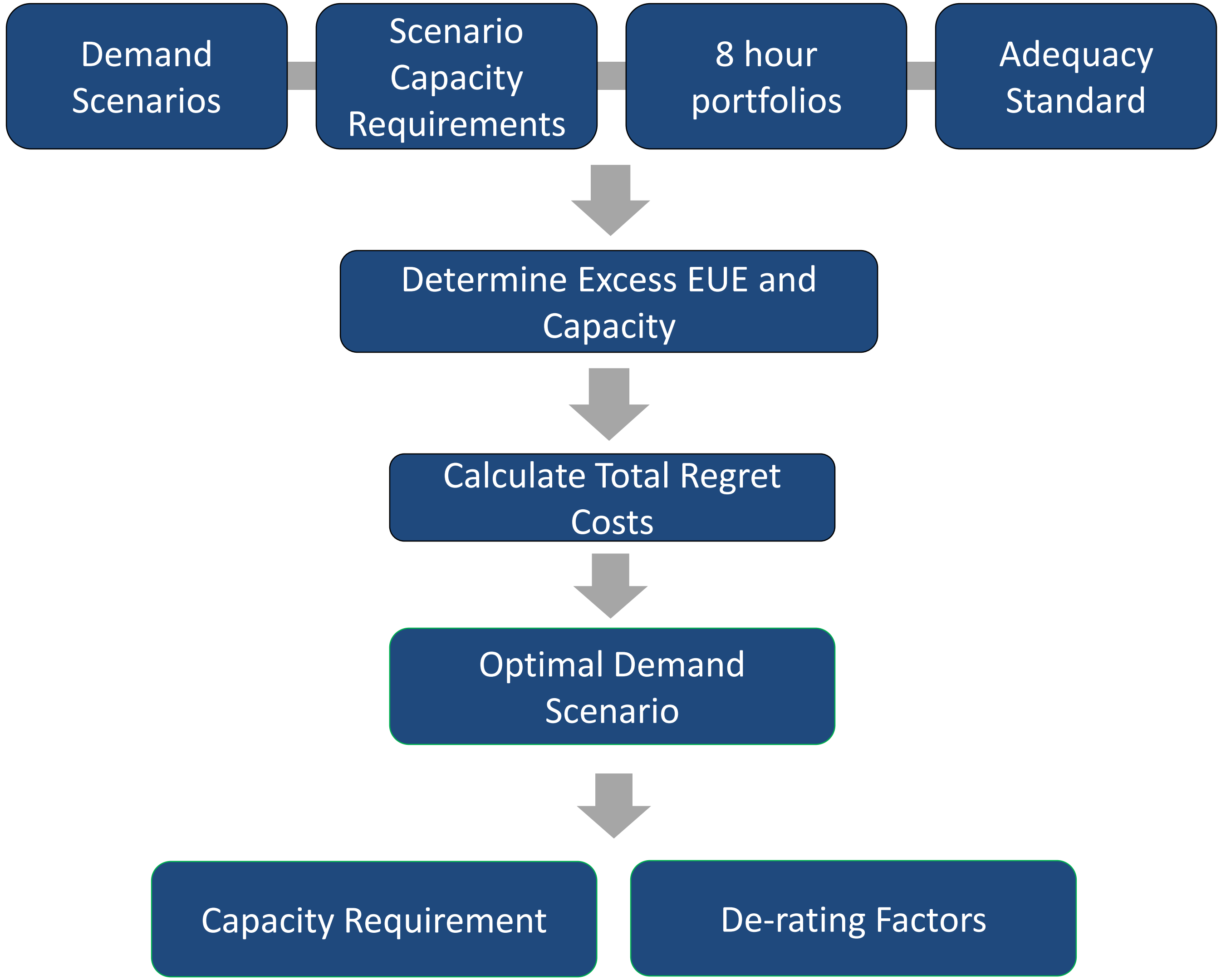
Under-Procurement vs. Over-Procurement

- The over-procurement regret cost is a linear function
- Under-procurement regret cost is a non-linear function.
- Significant under-procurement leads to very high costs
  - Frequent load shedding
  - More acute in a small system
  - Figure on the right is an example from one scenario
- The results show that least-worst regrets analysis tends to selecting demand scenario above the central scenario



Illustrative Example

Least-Worst Regrets Analysis



Indicative Results

Indicative results of the methodology

Indicative Results: Capacity Requirements

- The table gives the demand forecast components and indicative results for the Capacity Requirement that result from the methodology for the capacity years 2017/18 to 2020/21

	2017	2018	2019	2020
GCS Low TER Peak Demand	6,767	6,778	6,793	6,821
GCS Median TER Peak Demand	6,888	6,938	6,980	7,038
GCS High TER Peak Demand	6,917	6,977	7,074	7,219
Small-Scale Non-market Adjustment	242	251	263	265
Low Market Peak Demand	6,525	6,527	6,530	6,556
Median Market Peak Demand	6,646	6,687	6,717	6,773
High Market Peak Demand	6,675	6,726	6,811	6,954
Reserve Requirement	444	444	444	444
Low Market Demand + Reserve	6,969	6,971	6,974	7,000
Median Market Demand + Reserve	7,090	7,131	7,161	7,217
High Market Demand + Reserve	7,119	7,170	7,255	7,398
Indicative Capacity Requirement	7,312	7,321	7,401	7,498

Indicative Results: De-rating Factors

- The table gives the indicative results for the de-rating factors that results from the methodology for the year 2020/21
- The impact of the outage statistics can be seen, for example, in the different de-rating factors for gas and steam turbines
- The size impact can also be seen as the 401-500 MW size class has a lower de-rating factor than the 001-100 MW size class

De-rating Factors (%)							
Size Class (MW)	Gas Turbine	Steam Turbine	Hydro	Storage	DSU-AGU	System-Wide	Wind
001-100	95.8	91.8	95.4	86.0	73.0	93.2	12.5
101-200	95.0	90.3	94.6	82.7	68.8	92.3	
200-300	94.0	88.3	93.4	74.4	64.1	91.2	
301-400	92.6	85.9	92.0	64.3	59.3	89.1	
401-500	91.1	83.1	90.3	54.2	54.4	87.0	

Summary of Analysis Methodology

- TSOs have engaged with the RAs to develop a methodology that delivers the SEM Committee decisions
- A number of demand scenarios have been developed
- A set of broad technology categories have been created
- De-rating factors are determined by calculating the unit's marginal benefit to system adequacy and this takes account of the unit's size
- Least-worst regrets analysis is used to select the demand scenario that is used to set the capacity requirement

Questions?