

RCUC Unit Commitment Tool

Generator Forum

3rd Feb 2011

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Overview

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UUC v RCUC

- Ex- Ante UUC Market run calculates MSQ (Market Scheduled Quantity) for each unit and takes account of the following
 - Price Quantity Pairs
 - No Load Costs and Start-Up costs
 - Technical Characteristics
 - Forecast System Demand
 - Forecast wind output
 - Energy Limits for energy limited plant such as Hydro Targets & Pumped Storage
- RCUC takes account of each of the above and the following when calculating the DSQ for each unit
 - **Reserve Requirements**
 - **North-South Tie Line restrictions**
 - **Specified Transmission Constraints Groups**
- Furthermore RCUC accurately models
 - Loading up and down rates from zero to Min Load (ignored in UUC)
 - Actual Ramp Rates (averaged in UUC)
 - Notification times (ignored in UUC)



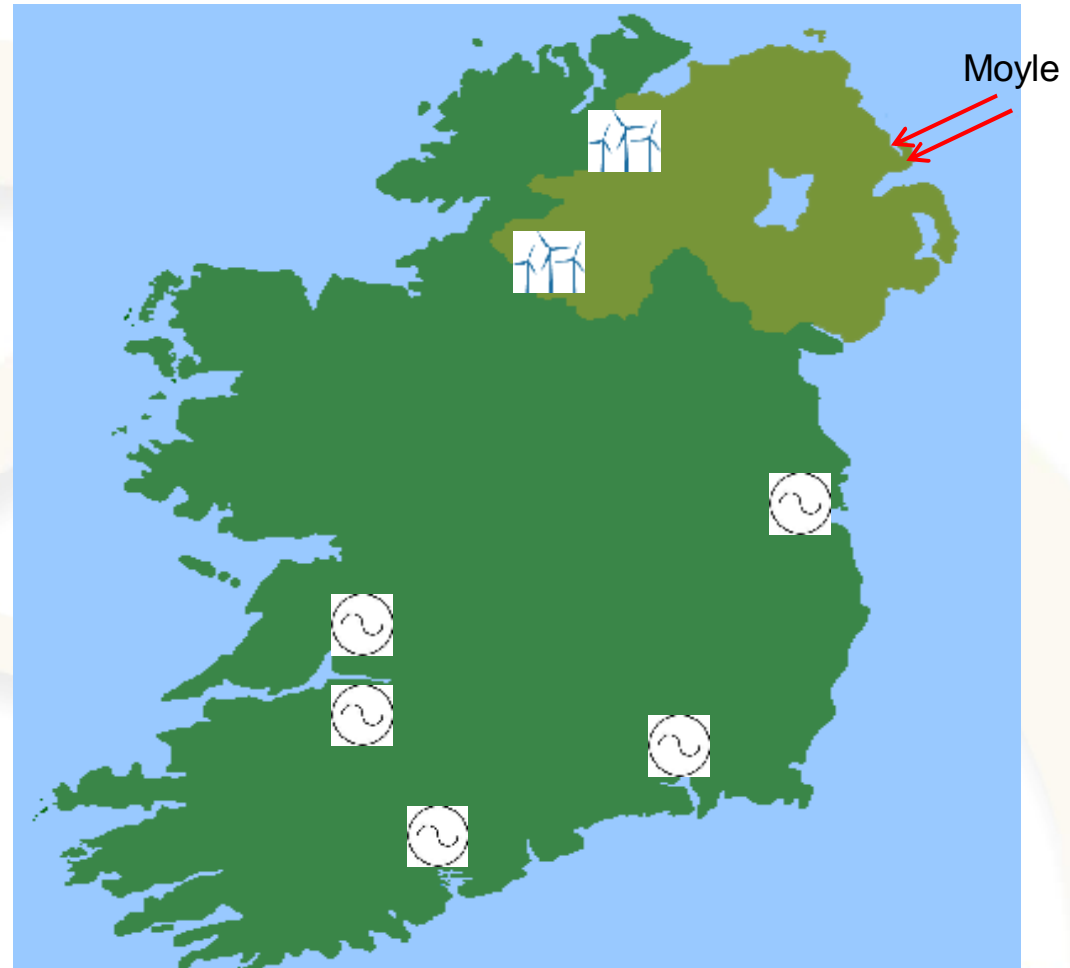
UUC v RCUC

UUC Output dispatches only thermal plant in ROI

Peak Load – 5428MW
Wind – 1071MW

The only generation in NI is from:

Wind – 196MW
Moyle – 238MW



UUC v RCUC

UUC Output

Time	NI Units	ROI Units	Moyle	Wind	Tie Line	System load
17:30	0	4119	238	1071	N/A	5428

RCUC Output

Time	NI Units	ROI Units	Moyle	Wind	Tie Line (S-N)	System load
17:30	744	2843	238	1091	199	4916

What is RCUC?

- Stands for **R**eserve **C**onstrained **U**nit **C**ommitment
 - ABB Software tool, used **only** by the TSOs, which utilises Linear Programming to perform Unit Commitment and Economic Dispatch
 - *“Put simply Linear Programming problems determine the way to achieve the best outcome (such as maximum profit or lowest cost) given some list of requirements represented as linear equations”.*
 - RCUC uses a Mixed Integer Program (MIP) to generate schedules where the total generation = total system demand at every trading period subject to a number of specified constraints whilst minimising the overall production cost
 - Has been in use since the Single Electricity Market went live on November 1st 2007



Purpose of RCUC

- **Purpose of Scheduling**

- To ensure there are sufficient generation resources committed to meet the forecasted system demand at all times
- To ensure that the output of the generation resources is such that all transmission plant is operated within acceptable limits
- To plan for credible contingencies on the generation and transmission system
- To provide information to Generators who have daily fuel purchasing commitments
- To feed into the real time dispatch process

The Schedule should:

- Minimise total production cost on the island whilst meeting all of the above requirements
- Be technically feasible
- Be produced and communicated in a timely fashion
- Be sufficiently flexible to allow for real time management of deviations from forecasted demand, wind generation and availabilities
- Be flexible enough to allow the operator to respond to real time events



Scheduling of RCUC

- A single 'all island' schedule is jointly produced by SONI and EirGrid
- Scheduling occurs in two separate time frames
- **Day-Ahead Schedules**
 - Jointly produced by the 'Day Staff' in SONI & EirGrid
 - Cover the time period from 06:00 on D up to 11:30 on D + 1
 - Completed and published by 16:00 on D-1
- **In-Day Schedules**
 - Jointly produced in real time by Control Centres in SONI & EirGrid
 - Day Ahead is updated with latest information and provides starting conditions for the 1st In-Day schedule at 06:30
 - In-Day schedules are produced at 10:00 and 21:00 approximately as updates to the following become available:
 - System Demand
 - Wind Generation
 - Availability of Plant
 - Transmission Plant operation
 - End time of the In-Day schedule is always 11:30 D+1, starting time may vary
 - Further In day and Day Ahead runs are produced as and when required (e.g. loss of large generator)



RCUC Reserve Requirements

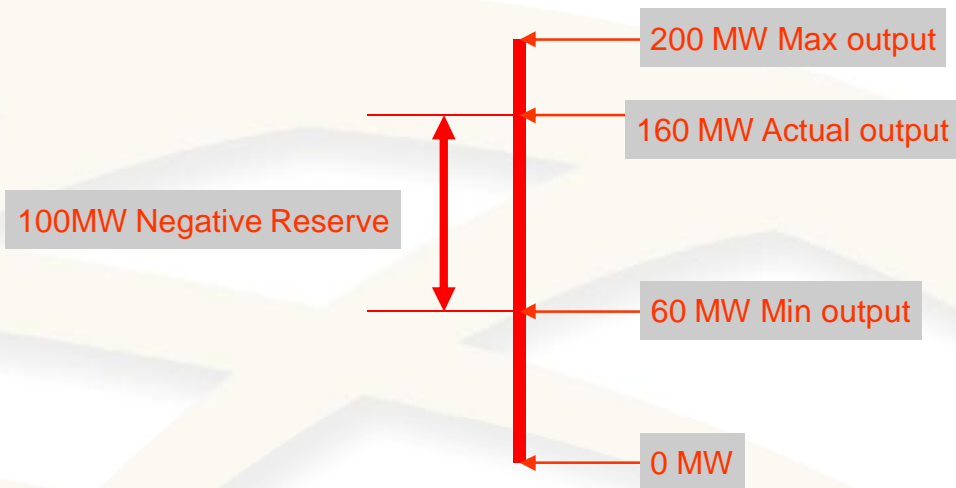
- **RCUC produces an optimised Unit Commitment schedule for the island**
- **RCUC co-optimises the provision of energy and the following five reserve categories**
 - Primary (5 -15 secs)
 - Secondary (15 - 90 secs)
 - Tertiary 1 (90 - 5 mins)
 - Tertiary 2 (5 - 20 mins)
 - Negative (Unit output minus the MSG)
- **Three other reserve categories are calculated by RCUC but not used in the optimisation**
 - Replacement (20mins – 4 hrs)
 - Substitute (4 – 24 hrs)
 - Contingency (+24hrs)



Negative Reserve

- Negative reserve was introduced to plan and monitor for unexpected increases in non dispatched generation i.e. wind
- The negative reserve is the difference between the combined running output of all synchronised machines and their minimum output, (most commonly referred to as 'min gen')
- Collectively this represents the 'head room' there is at any one point in time for the system to absorb increasing non dispatched generation

Negative Reserve



For Example:

- The total generation scheduled may be 4000 MW and without taking units off, reducing the unit outputs to minimum could reduce the total output to 3300 MW . Therefore there is 700 MW of negative reserve available.
- If the non dispatched generation (wind) was capable of increasing by more than 700 MW, additional operator action is required, which could mean desynchronising a machine to restore target frequency.

RCUC Reserve Requirements

RCUC schedules units to provide reserve for the island at minimum system cost based on individual unit reserve characteristics respecting –

- 1) A jurisdictional minimum primary reserve holding for SONI**
- 2) A jurisdictional minimum primary reserve holding for EirGrid**
- 3) A total island reserve requirement determined from a fixed percentage of the Largest Single Infeed (LSI), typically 81%**
- 4) Tie line flow limits after reserve execution in either jurisdiction**



Jurisdictional Reserve Requirements

1) A jurisdictional minimum primary reserve holding for SONI

2) A jurisdictional minimum primary reserve holding for EirGrid

These values are fixed and are to -

- permit control of the tie line flows
- avoid uncontrollable frequency falls in the event of system separation i.e. if the tie lines between the NI and ROI should trip

Present values are: SONI – 50MW all day

EirGrid – 120MW day, 145MW night

This reserve can only be provided from dynamic sources



All Island Reserve Requirements

3) A total island reserve requirement determined from a fixed percentage of the Largest Single Infeed (LSI), typically 81%

The loss of the LSI is the event planned for when quantifying reserve provision.

The LSI includes the Moyle import.

If reserve is being carried on the LSI, this reserve is not included in reserve totals

RCUC will reduce the output of the LSI source if it is a cheaper solution than providing additional reserve.

The balance of the reserve requirement (total minus jurisdictional minima can be optimised and scheduled in either jurisdiction)

Present values are -

Primary	81% LSI	Secondary	81% LSI
Tertiary 1	100% LSI	Tertiary Reserve 2	100% LSI



Tie Line Limits

4) Tie line flow limits after reserve execution in either jurisdiction

Tie line flows in both directions have physical limits, the maximum flow that can be sustained without breaching system security rules (line overloads, voltage limits etc) after a credible transmission event

The limits are referred to as the Total Transfer Capacity (two values one N-S and one S-N)

When determining minimum system cost, RCUC respects the TTC values by not allowing the reserve holding in either jurisdiction + the tie line flow to exceed the TTC

Present values (normal operation)	N-S TTC	450 MW
	S-N TTC	400 MW

Dynamic/Static Reserve

Dynamic

- Synchronised units operating at less than maximum output
- Pump storage synchronised and generating

Static

- Pump storage in pump mode (Turlough Hill)
- Moyle interconnector
- Interruptible Load

RCUC Constraints

RCUC is a optimisation tool **not** a system security constrained tool

To make RCUC reflect physics and our prudent system operation we must apply constraints

RCUC is constrained in two areas:

- System balance: Generation = Demand (whilst considering reserve)
- Physical Unit constraints: e.g. Minimum up/down times, MSG, load up rates, ramp rates etc

Additional constraints are then imposed by the TSO's called Transmission Constraint Groups (TCGs)



TCGs

RCUC has three TCG types:

MW: TCG applies a limit to the total MW output from a unit or group of units

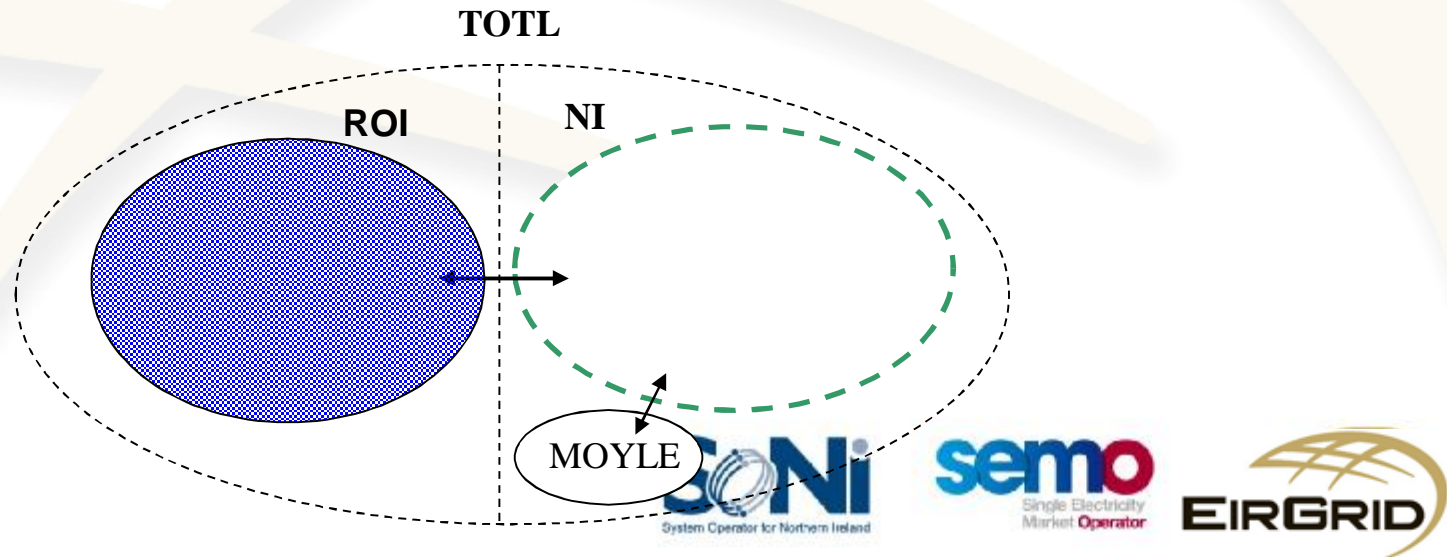
MWR: Inter-area constraints between SONI and EirGrid (Tie line flow) including reserve

NB :Limits for the number of units online in an area



TCGs

- **TOTL** is of MW type which contains all units on the island and is used to balance total generation with total demand
- **ROI** is of MWR type which contains all EirGrid units and is used to control the flow S-N
- **NI** is of MWR type which contains all the SONI units (including Moyle) and is used to control the flow N-S
- **Moyle** is of MW type which contains the Moyle interconnector units and is used to limit it's import to NI and export to GB



Most Common TCGs

The most common constraints that are modelled are:

- North – South Tie line export / import constraint: MWR type
- Moyle Import/Export constraint: MW type
- Requirement to keep a minimum number of units on in an area: NB type
- Requirement to limit the output of the generators in an area to limit short circuit levels or overloads: MW type or NB type
- Requirement to enforce the minimum output from the generators in an area to support the voltage or to avoid overloads: MW type or NB type
- Requirement to limit the output of stations due to salmon spawning: MW type



Active SONI TCGs

Name	TCG Type	Limit type	Limit	Resources	Description
MINNIU	NB	N:>=	3 all day	All units in NI (excluding OCGTs)	There must be at least 3 units synchronised at all times in NI <i>Required for system security</i>
NI_GT	MW	X:<=	195MW all day	BGT1,BGT2, CGT8,KGT1, KGT2,KGT3, KGT4	Combined MW output of OCGTs must be less than 195MW <i>Required for system security</i>
KILROO	NB	N:>=	1 all day	K1,K2	There must be at least 1 unit synchronised at all times <i>Required for voltage support</i>
BPSMAX	MW	X:<=		B31,B32,B10, B4,B5,B6, BGT1,BGT2	The combined output of all units in Ballylumford must not exceed: 1194MW (Dec to Feb inclusive) 1024MW (Mar to Nov inclusive) <i>Transmission Constraint at Substation</i>
CPS_N / CPS_X	MW	B: <= & >=	260MW – 425W	C30	C30 must be synchronised at all times <i>Required for System stability and voltage support in the North West</i>
B31B32	N	N:>=	1 all day	B31, B32	There must be at least 1 unit synchronised at all times <i>Required due to mechanical issue with plant</i>

Active EirGrid TCGs

Name	TCG Type	Limit type	Limit	Resources	Description
System Stability	NB	N:>=	5 units	AD1, AD2, DB1, HNC, HN2, MP1,MP2,MP3, PBC, TB3, TB4, TYC, WG1	There must be at least 5 high inertia machines on-load at all times in ROI <i>Required for dynamic stability</i>
Replacement Reserve	MW	X:<=	489 MW	AT11, AT12, AT14, ED3, ED5, MRC, NW5, RP1, RP2,TP1,TP2	Combined MW output of OCGTs must be less than 489MW (out of a total of 789 MW) in ROI at all times <i>Required for replacement reserve</i>
Dublin Generation	NB	N:>=	2 in winter 3 in summer	DB1, HNC, HN2, PBC	There must be at least 2/3 large generators on-load at all times in Dublin area <i>Required for voltage control</i>
Poolbeg Must Run	NB	N:>=	1 unit	PBC	PBC must remain on-load at all times <i>Required for system security (voltage control, reserve contribution and transmission support)</i>

Active EirGrid TCGs cont'd

Name	TCG Type	Limit type	Limit	Resources	Description
South West Generation	NB	N:>=	3 by day 2 by night	AD1, AD2, AT11, AT12, AT14, MRC, SK3, SK4, TB1, TB2, TB3, TB4, WG1	There must be at least 3 units on load in the South West <i>Required for voltage stability</i>
	MW	N:>=	240 MW by day only	AD1, AD2, AT11, AT12, AT14, MRC, SK3, SK4, TB1, TB2, TB3, TB4, WG1	There must be at least 240 MW of generation on-load in the South West by day <i>Required for system security (overload security criteria)</i>
Cork Generation	MW	X:>=	800 MW	AD1, AD2, AT11, AT12, AT14, WG1	This restricts the amount of generation in the Cork area to 800 MW <i>Required due to transmission congestion</i>
Moneypoint	NB	N:>=	1 unit	MP1, MP2, MP3	There must be at least one Moneypoint unit on load at all times <i>Required to support the 400 kV network</i>

Active EirGrid TCGs

Name	TCG Type	Limit type	Limit	Resources	Description
Turlough Hill	MW	Between	10 -140 MW by day -220 – 0 MW by night	TH1, TH2, TH3, TH2	This forces Turlough Hill to generate by day and pump by night <i>Required for system stability (reserve contribution)</i>
	NB	N:>=	2 by day 1 by night	TH1, TH2, TH3, TH2	Ensures that 2 generators on by day and 1 by night <i>Required for system stability (reserve contribution)</i>
Hydro smolts	MW & NB	Various	During spring & early summer periods	Ardnacrusha, Erne & Lee	Restricts dispatch of hydro generation over spring and early summer periods <i>Required to facilitate the passage of smolt downstream and elver upstream</i>