A New Unit Commitment Model Considering the Ramp Trajectory

Mingsong Li[1] (mingsong.li@ucdconnect.ie)
Supervisors: Paula Carroll[2] (paula.carroll@ucd.ie), **Damian Flynn**[1](damian.flynn@ucd.ie)
[1]*UCD School of Electrical, Electronic and Communications Engineering* [2]*UCD School of Business*

Introduction

- In Ireland and Northern Ireland, all trades are completed within the mandatory gross pool of the Single Electricity Market, and the main electricity commodity purchased and sold is energy (MWh).
- In the day-ahead UC, the solution is based on a stepwise demand function, based on the energy-block trading in the market. This stepwise function can cause "**infeasible energy delivery**" in the conventional UC model, i.e. the scheduled energy output cannot be realised by the units when they obey the related physical ramping and operating constraints.

Objective(s):

- **Create a new MILP UC model considering instantaneous power and energy-block separately to conquer the "infeasible energy delivery" problem.**
- **To guarantee a feasible energy delivery as required by the energy-block bidding, that matches the energy generation and demand in hourly time resolution.**

Methodology

- Stepwise energy demand is employed in the conventional UC model, which supposes that a unit's power can instantaneously change at the intersection of two adjacent periods, while within one period, the power trajectory follows a constant linear function.

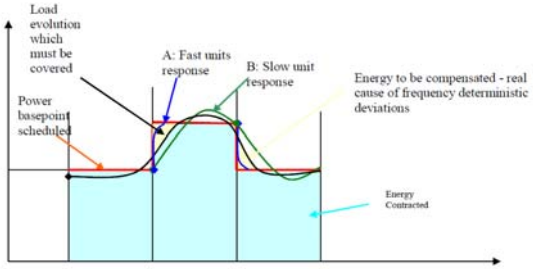

Figure 1: Unit Behaviour in Scheduled Time Frames. Source: Transelectrica

- In reality, the power trajectory is a continuous and dynamically changing curve.
- For a given unit, if we know the power level at the end points of one period, the maximum and minimum energy delivered can be calculated.

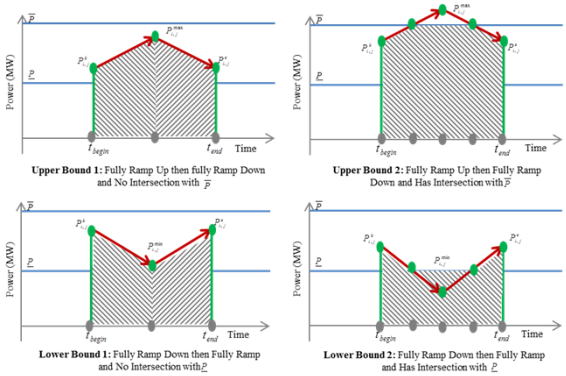

Figure 2: Boundaries of Deliverable Energy within One Period

Results

Table 1: Comparison of Computational Dimension and Results

	Conventional Model	New Model		Conventional Model	New Model
# of Variables	7338	29436	Best Bound	573942	579388
# of Constraints	2640	18000	Best Solution	573942	585281
# of Nonzero Elements	35706	97954	Gap (%)	0	1.007
# of Global Entities	720	4800	Time (s)	2.6	7200

The proposed new MILP model has been tested on the 10 units system given by (Kazarlis et al., 1996), and the spinning reserve is assumed to be 10% of the demand. Longer time is consumed to solve the more complicate new model compared with the conventional model (Table 1).

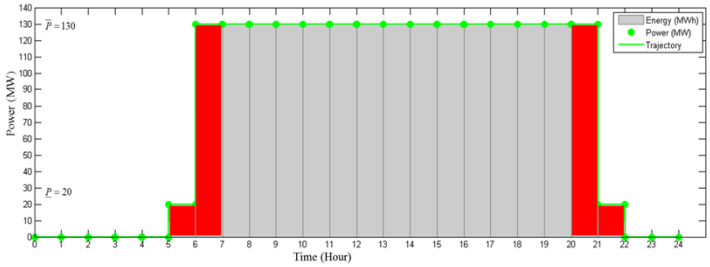

Figure 3: Unit 3 Energy Delivered and Instantaneous Power from Conventional Model

From the conventional UC model (Figure 3), the scheduled energy for Unit 3 in hour 6 and hour 7 are 20 *MWh* and 130 *MWh* . Due to its capacity and ramp capability 110 *MW/h* , there will be an "**infeasible energy delivery**" problem in practice. The power trajectory is required to follow a stepwise function, which is unrealistic.

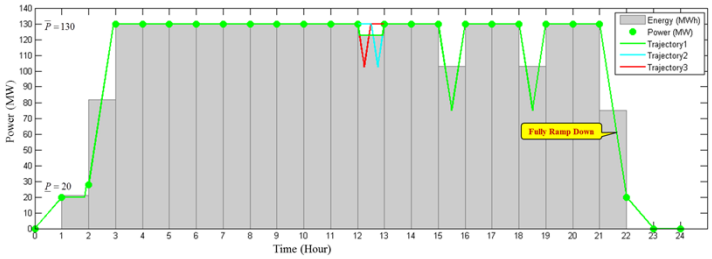

Figure 4: Unit 3 Energy Delivered and Instantaneous Power from New Model

From the new UC model (Figure 4), the scheduled energy for Unit 3 in hour 22 is 75 *MWh*, which corresponds with the power level ramping down from 130 to 20 *MW* within this period.
To deliver a given amount of scheduled energy in one period, the power trajectory is not unique, such as in hour 13, trajectory 1, trajectory 2, trajectory 3 can deliver the same amount of energy.
All the power trajectories are continuous and dynamically changed subject to the ramp capability.

Conclusions

- A novel MILP formulation of Unit Commitment considering instantaneous power and energy-blocks separately is proposed. No specific power trajectory should be follow.
- The ramp up/down process is accurately formulated, as well as the impact of a ramping trajectory on energy delivery.
- This model ensures feasible energy delivery as required by the energy-block bidding, with a match between the (energy) generation and hourly demand.

Acknowledgement

This work was conducted in the Electricity Research Centre, University College Dublin, Ireland, which is supported by the Electricity Research Centre's Industry Affiliates Programme (http://erc.ucd.ie/industry/).

Mingsong Li is funded through Science Foundation Ireland Grant Number SFI/09/SRC/E1780.