Single Electricity Market

SMP Uplift Parameters

Decision Paper

15th March 2007

AIP/SEM/07/51

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1. INTRODUCTION AND BACKGROUND

This Decision Paper relates to the consultation paper "SMP Uplift Parameters" (AIP/SEM/230/06), published by the Regulatory Authorities on 22 December 2006.

Version 1.0 of the SEM Trading and Settlement Code stated that Start-Up and No-Load costs will be included in the calculation of System Marginal Price (SMP), but did not set out the methodology for this inclusion.

Four options (referred to as Options A – D) were documented in the paper "SMP Uplift: Update" (AIP/SEM/60/06) published on 25 May 2006, and were subsequently presented by the Regulatory Authorities to the Rules Liaison Group in June 2006.

Following an industry consultation, on 18 September 2006 the Regulatory Authorities published a Decision Paper "Objectives of Function to Include Start-Up and No-Load Costs in SMP" (AIP/SEM/142/06), in which was set out the decision of the Regulatory Authorities as to the objectives of the methodology for setting SMP, based on the "shadow prices" generated by the Unit Commitment software.

The Regulatory Authorities procured the modelling of Options A – D in order to evaluate the suitability of each Option against these objectives. The results of this modelling were presented in AIP/SEM/230/06, and comment was sought from industry as to which of Options A – D should be implemented and, in the event that Option D is selected, what values should be assigned to its parameters.

The Regulatory Authorities noted in AIP/SEM/230/06 a number of issues for further investigation, and additional modelling has been conducted in order to address these matters.

We now summarise the responses to AIP/SEM/230/06 that were received, discuss the outcomes of this additional modelling and investigation, and present the decision of the Regulatory Authorities.

2. RESPONSES

Responses were received from:

- AES Kilroot

- Airtricity

- Aughinish Alumina Limited

- Bord Gáis Energy Supply

- ESB Customer Supply

- ESB Power Generation

- ESB Independent Energy

- Northern Ireland Electricity plc

- Viridian Power and Energy

In relation to the Option and parameters to be selected, the following comments were received:

Item	Comment
Option	Airtricity and ESBIE supported the choice of Option D.
CUW	VPE favoured a value below 0.01, ESBIE favoured a value of 0.1 and ESB Customer Supply favoured a value of 0.3.
δ	Airtricity and NIE rejected the need for this parameter. ESB Customer Supply regarded a value of 0.2 as appropriate. ESBIE favoured a value of 1.

The responses also included a number of comments that did not directly touch upon a particular Option or parameter value. These are now set out by general theme, along with the position of the Regulatory Authorities in relation to each.

2.1   Need for Further Analysis

A number of respondents expressed the view that the analysis carried out to date does not represent a sufficient basis upon which to make a final decision on the Option and parameter values.   AES Kilroot suggested that a Monte Carlo framework would have yielded more robust modelling results than the "static set of prices" used by the Regulatory Authorities.

The Regulatory Authorities take the view that while some additional modelling was necessary (and has now been completed), a full Monte Carlo framework would neither be feasible nor desirable. The uplift modelling takes as its inputs a market schedule with associated generation costs, and then applies the uplift formula to calculate a set of SMP values. By varying the uplift parameters, a range of uplift outcomes can be produced, and the range of results using different uplift parameter values was shown within AIP/SEM/230/06. The resolution of the uplift algorithm itself has been found to be stable, with the uplift model quickly finding a set of results for any given set of input data.

There has deliberately been no attempt to apply Monte Carlo techniques to the Plexos model runs which provide the inputs to the uplift modelling. Monte Carlo techniques permit the estimation of probability distributions of model outputs when the distributions of the inputs to the model are themselves known, and where these distributions can be used to generate a large number of input vectors. However, the value of such an approach is questionable in the context of determining the uplift parameters because:

- each model run covers a set of 365 days, which will itself include a variety of circumstances;

- it is unlikely that the performance of the uplift algorithm under different parameter inputs is sensitive in any meaningful way to the inputs to the dispatch model (such as fuel prices) which could be varied in a stochastic manner, and it is not clear that any meaningful information on the performance of the uplift algorithm would be revealed;

- Monte Carlo techniques would multiply the volume of data considerably, which would giver rise to logistical difficulties; and

- the use of Monte Carlo techniques would place greater reliance on averaged results, thus reducing the extent to which the analysis could consider individual daily SMP profiles.

While the application of a Monte Carlo approach to the All Island Modelling programme would perhaps give some information on the distribution of the shadow prices, it is unlikely to change the general pattern of uplift and resultant SMP values.

2.2 Basis for Decision

A number of respondents expressed the view that parameters should be set based on modelling carried out using outputs from the central market system, including those generated during its testing phase.

The Regulatory Authorities have, in carrying out modelling and analysis on the issue, striven to replicate the outputs that will be generated by the central market system. They are satisfied that this approach represents a satisfactory basis for the selection of the appropriate parameter values.

2.3 International Precedent

It was suggested that explicit regard should have been had to the solutions that have been implemented in energy markets around the world in order to fund generators' start and no-load costs by way of an uplift mechanism.

The Regulatory Authorities acknowledge that a variety of uplift mechanisms exist in other energy markets, but believe that no single "best practice" exists in relation to the design of such mechanisms, and that the options referred to in AIP/SEM/230/06 achieve the objectives for uplift as set out in AIP/SEM/142/06.

2.4 Price Spikes

ESB Customer Supply requested access to the raw hourly shadow price and uplift data used in the modelling, to enable it to satisfy itself that the incidence of "spurious" price spikes under any particular parameter configuration is tolerably low.

The Regulatory Authorities did, on 15 January 2007, publish such data as part of the uplift model published on the All Island Project website (at http://www.allislandproject.org/2007/uplift.zip), although it is possible that some participants may not have had the opportunity to incorporate an analysis of this information into their responses.

Aughinish Alumina Limited expressed the concern that because the quadratic element of the uplift algorithm operates over an optimisation period comprising 48 trading periods, this could in theory lead to a very large half-hourly price variance (between shadow price and SMP) in one period in the day, coupled with near zero variances in other periods. It was suggested that this could occur if multiple units, which started at different times during the day, are all scheduled on during a single period, and it was proposed that if a start occurs in a trading period, some element of the cost should be applied to that period.

The Regulatory Authorities note that the principle suggested by Aughinish, which would require some element of start costs to always be recovered in the period in which a unit starts, is difficult to justify. For example, a unit might be required to operate at full load for the morning peak, and might therefore be required to start earlier so that it can reach full load in time for the peak, before then shutting down. The unit is effectively "constrained on" in its start period (the constraint being inter-temporal in nature) and the recovery of its start costs can justifiably be weighted towards the morning peak rather than some pre-determined proportion being recovered within the start period.

Airtricity expressed the view that the parameters should be chosen so as not to cause "unreflective prices spikes".

The Regulatory Authorities have further investigated the incidence and causes of price spikes. Our findings are that the application of the 'revenue minimising' term in the uplift algorithm tends to push uplift into narrow periods, whereas the quadratic 'profile' term tends to smooth the resultant uplift profile. This is discussed in more detail below.

2.5 Measurement of the Profile Objective

Aughinish Alumina Limited, ESB Power Generation and Northern Ireland Electricity plc requested that the correlation coefficients between shadow price and SMP be calculated, published and used in the analysis of the parameters.

The "goodness of fit" measure reported in AIP/SEM/230/06 used a basket of elements, including:

- Sum of uplift squared;
- Correlation between shadow price and uplift;
- Correlation between shadow price and SMP;
- Correlation between the change in shadow price from hour H-1 to hour H and the change in uplift from hour H-1 to hour H; and
- Correlation between the change in shadow price from hour H-1 to hour H and the change in SMP from hour H-1 to hour H.

The correlation between shadow price and SMP was, together with a number of other correlations, used in the analysis of the parameters. The hourly profiles of uplift and SMP were also made available as part of the model published in January 2007, from which any additional correlation values could be calculated.

The modelling reported within AIP/SEM/230/06 used a basket of measures because no single correlation can be regarded as a complete measure of the 'quality' of an SMP profile. It was found in modelling the profile objective that the "goodness of fit" results were insensitive to the choices and the way in which these measures were combined.

2.6   Governance of Uplift Parameters

Aughinish Alumina Limited requested that any chosen parameter values be written into the SEM Trading and Settlement Code so that their amendment would be subject to the modification process that will generally be applicable to the Code. This request was made on the basis that to allow the Regulatory Authorities to modify such parameters without submission to such procedure would increase regulatory and investment risk. Bord Gáis Energy Supply regarded the "[manipulation of] the market prices" by the Regulatory Authorities through their control over the parameters as undermining a market-based approach to price setting.

The Regulatory Authorities take the view that it would not be correct to regard any adjustment of a parameter value as an action intended to manipulate market prices, due to the complicated nature of the relationship between uplift parameters and the absolute SMP values.

The Regulatory Authorities believe that it is appropriate for them to retain the function of determining the values of the uplift parameters, and it would therefore not be appropriate to include specific parameter values in the Code (to which

they are not parties). The Regulatory Authorities further consider that to provide outside the TSC for specific parameter values does not preclude or impair due process. In the short term following SEM go-live, and having regard to the apparent sensitivity of the algorithm to the underlying schedule, it should be noted that the Regulatory Authorities wish to leave open the possibility of further adjustment being made to the parameters once data on the operation of the central market system's scheduling algorithm becomes available, and for the reasons set out on p18 of AIP/SEM/230/06. Any such change would be subject to appropriate levels of industry consultation.

2.7   Minimum Cost Recovery Period

Aughinish Alumina Limited expressed concern at the Regulatory Authorities' suggestion on p18 of AIP/SEM/230/06 that a minimum level of operation may need to be imposed, over which the start and no-load costs of a particular generator must be distributed. They describe such a provision as the introduction of an artificial constraint into the SEM scheduling algorithm, and suggest that a mechanism other than the amendment of the scheduling algorithm should be used to pursue "such distributional objectives". Northern Ireland Electricity plc also expressed concern at this suggestion, and described it as anticipating a flaw in the unit commitment algorithm.

The Regulatory Authorities note that the suggestion is not primarily intended to address sub-optimal scheduling behaviour, and should not therefore be regarded as an amendment to the scheduling algorithm. Rather, it is intended to address price spikes to the extent that these can be argued to arise due to a feature of the uplift (as opposed to scheduling) algorithm, and which could cause the resultant SMPs not to reflect underlying market conditions.

These circumstances may arise without being caused by flaws in the scheduling algorithm. The present rule for uplift (irrespective of the value of the CUW and independent of whether Option A, B, C or D is implemented) is that each unit must recover its scheduled operating cost from SMP revenue in that period of continuous operation. The strict application of this rule could introduce some pricing anomalies, such that (at the margin) SMP could increase sharply as system demand decreases, and vice versa. This would violate standard microeconomic assumptions by suggesting that "marginal" costs (here including start and no load costs spread across output) fall over a range of increasing output (and at times are discontinuous), and could result in price spikes that are

not consistent with the marginal cost of production, but rather with the average cost of production of the relevant unit.

Consider the case in which a unit is started for a single trading period and run at a level of output (X MWh) to meet the demand peak, then shut down. If the associated cost of starting the unit in that hour is €Y (assuming that incremental costs are very low), then the uplift algorithm (or the alternatives considered) will ensure that SMP is at least equal to Y/X. If demand were one MWh lower, but the unit was still required to run, the uplift algorithm would ensure that SMP was at least equal to the higher value of Y/(X-1). At very low levels of output by the marginal plant, the start cost could lead to very large (and potentially distorting) spikes in SMP which would be highly sensitive to the exact level of system demand and the availabilities of other units.

The Regulatory Authorities have an action under the SEM to select a value for the Market Price Cap[1], which will potentially have the effect of mitigating such price spikes. This cost recovery issue is likely to be considered in the setting of this cap. It should be noted that any start or no-load costs that are not recovered by a generator due to the effect of the Market Price Cap will be reflected in the calculation of make-whole payments under the Code.

2.8   Infra-marginal Rent

Viridian Power and Energy expressed the concern that the incentives for improving generator efficiency and reducing related emissions are reduced and in some cases possibly eliminated by the inclusion of infra-marginal rent as part of the cost recovery constraint for each generator. VPE suggest that in relation to a period in which uplift is positive, an improvement in the start or no-load efficiency of the generator that is "causing" the positive uplift (which improvement is not sufficient to alter the schedule, and which does not affect the commitment or the shadow price) would reduce the amount of uplift paid, and that this fails to incentivise such a firm to seek improvements in efficiency.

However, the caveat that the change in efficiency does not alter the commitment or the shadow price is restrictive – at some level, changes in start or no load costs will change the unit commitment and the shadow prices, and generators will compete on these elements of cost as well as incremental prices.

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[1] See for example the definition of "Market Price Cap" in v1.2 of the SEM Trading and Settlement Code (AIP-SEM-07-07).

Essentially, a unit which sets uplift is being treated as marginal over that period of operation, and the uplift algorithm as formulated mimics the operation of a conventional market in which all costs can be expressed as marginal with the level of output.

Consider the treatment of a marginal generator in a market without start or no load costs or inter-temporal constraints. The marginal generator will set market price at its submitted incremental bid. If it changes its efficiency and continues to submit a cost-reflective bid price, then over a narrow range of reduced bids (within which range the efficiency improvement is not sufficient to alter the schedule and does not affect the unit commitment or the shadow price), it will continue to receive a price set by its own marginal cost and will be indifferent to the outcome. However, its incentive to improve efficiency is that by doing so it increases the chances that it will become infra-marginal at any time. By making the assumption that such changes do not affect dispatch, this important incentive is assumed away.

For these reasons, the Regulatory Authorities believe that allowing the recovery of infra-marginal rent does incentivise firms to improve plant efficiency.

3.   FURTHER MODELLING

3.1   SMP Profile

AIP/SEM/230/06 included the following qualification (at p18):

> *"As was stated in AIP-SEM-142-06 (at p4), the actual operation under SEM of the unconstrained scheduling algorithm has yet to be tested, and it is possible that units with high start-up costs may be scheduled at low output levels for short-periods of time. This may cause generator units to recover their costs over short periods of operation, resulting in price spikes unreflective of the underlying conditions in the market. It may be necessary to impose a minimum level of operation across which a generator can recover its costs. This issue will be monitored as data on the operation of the algorithm becomes available.* "

Following the publication of AIP/SEM/230/06, the Regulatory Authorities reviewed the modelling on which the consultation was based, and in particular the underlying dispatch schedule. This dispatch schedule was created during the LOOP2 Plexos run[2] and was found, on inspection, to contain a large number of anomalous and apparently sub-optimal dispatch decisions that could be expected to have a considerable impact on uplift, most notably by causing ostensibly 'spurious' price spikes.

It was also found that the SMP profiles generated during the AIP/SEM/230/06 modelling process did in fact include large price spikes on a significant number of days. This was the case even when the recommended parameter values (CUW = 0.3, δ = 0.2) were used.

In light of this, the Regulatory Authorities commissioned further modelling of the uplift algorithms with two significant modifications:

- improvements to the underlying schedule; and
- revised parameter values.

The Regulatory Authorities do not, by reason of the presentation of the results of this modelling in this paper, make any representation as to the likely or expected

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[2] It was noted in AIP/SEM/230/06 (at p4) that this data set was generated during the LOOP2 run, but that it is not the same as the LOOP2 Modelling Results that were also generated from that run (see http://www.allislandproject.org/loop2modelling.html).

magnitude or variability under SEM of SMP, shadow prices or uplift, or indeed any output of the market scheduler.

3.2   Improved Schedule

A number of adjustments were made to the operation of the Plexos scheduler, including the block-loading of peaking plant (avoiding the scheduling of peaking plant at low levels of operation) and the use of the "rounded relaxation" mode.

Separately, filters were applied such that units which, for a continuous operating period, were scheduled not to exceed their minimum stable generation level, were excluded from the analysis in respect of that continuous operating period.

3.3   Revised Parameter Values

With the new schedule as an input, the Regulatory Authorities then reviewed the appropriate values for α, β and δ, using the behaviour of the SMP profiles as a qualitative indicator of the performance of the algorithm under various alternative parameter values.

From AIP/SEM/230/06:

$$\text{CUW} = \frac{\alpha \text{ (Cost weight)}}{\alpha \text{ (Cost weight)} + \beta \text{ (Profile weight)}}$$

Figure 1 compares, for each of four representative trading days, SMP profiles for CUW = 0.3 (red line) and CUW = 0 (blue line). In all cases δ has been set to 5.
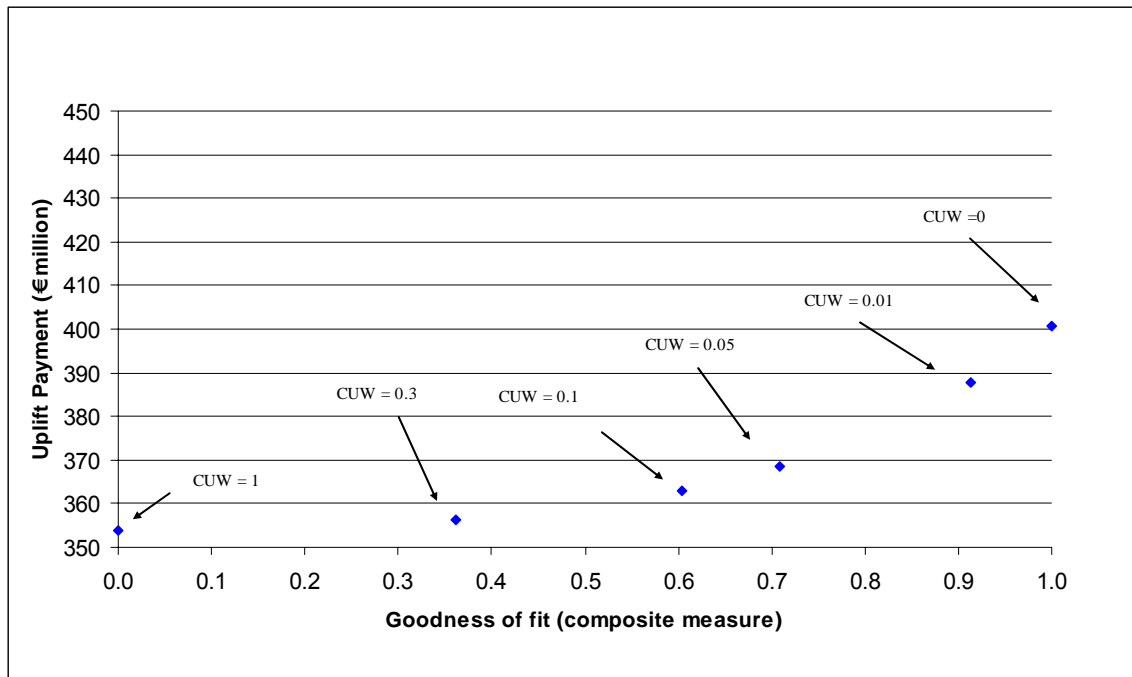
Figure 1: Effect of Revised Parameters
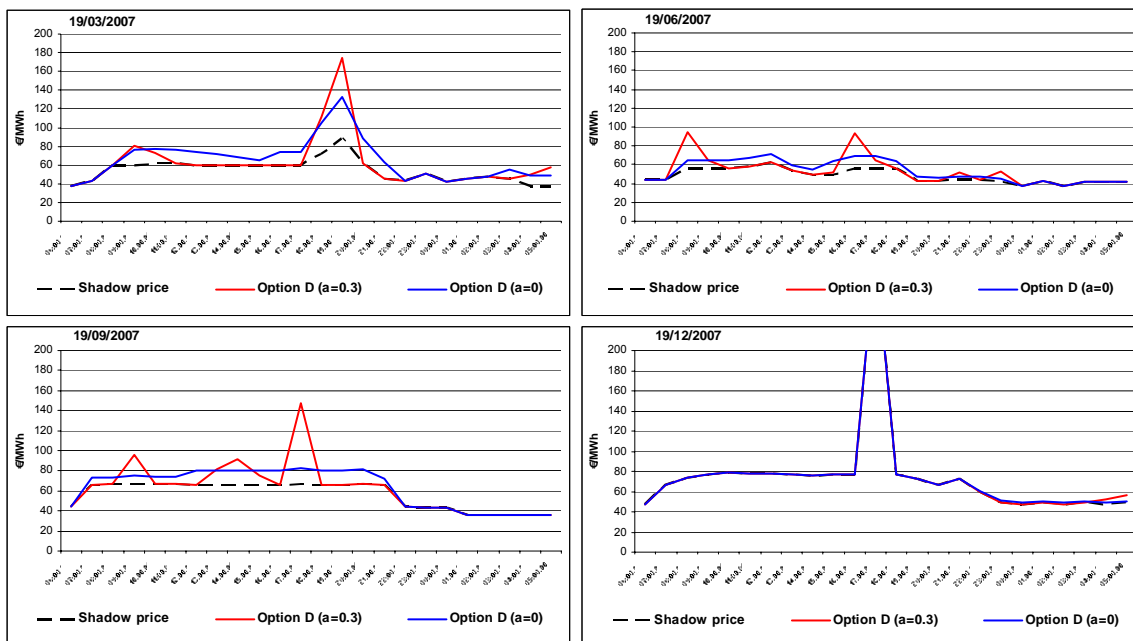
Source: Pöyry Energy Consulting

Figure 2 presents cost versus 'goodness of fit' in relation to the new modelling exercise, using the basket of measures that was developed and explained in AIP/SEM/230/06.
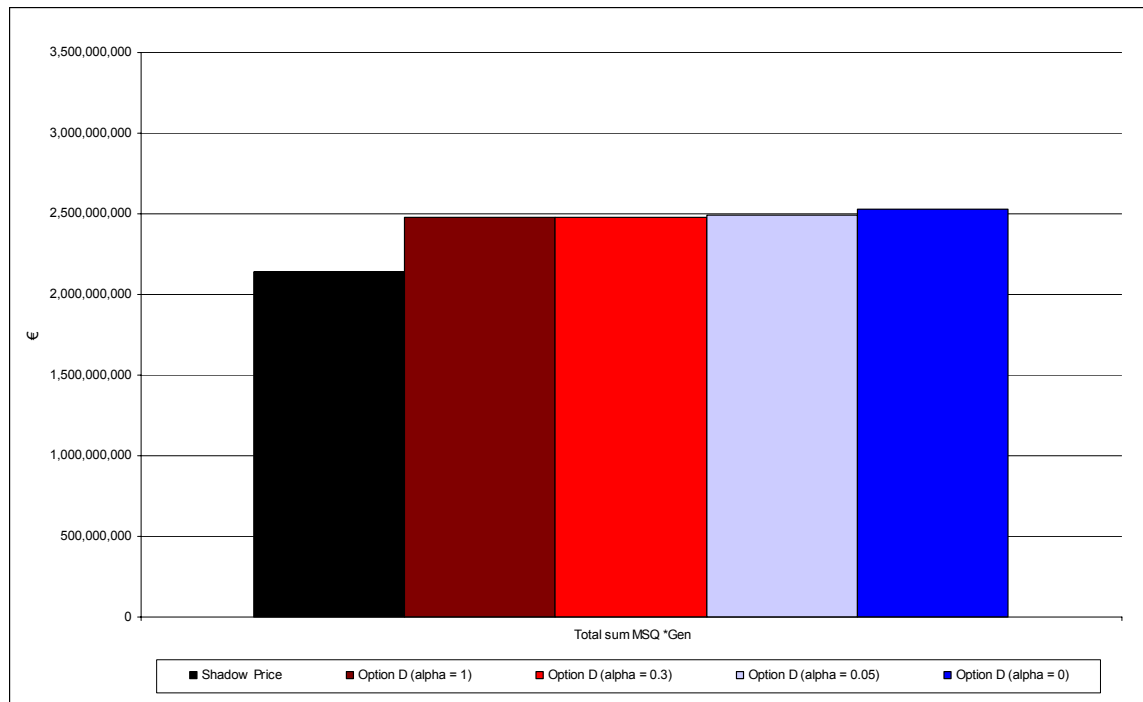
Figure 2: Uplift Revenue v Goodness of fit

Source: Pöyry Energy Consulting

Figure 3 and the accompanying table below show the impact of alternative values of α on annual SMP revenue, uplift revenue and the time-weighted average SMP.

Figure 3: Shadow Price and Total SMP Revenues

	Shadow Price	Option D (alpha = 1)	Option D (alpha = 0.3)	Option D (alpha = 0.05)	Option D (alpha = 0)
Total revenue (€)	2,143,129,945	2,478,402,824	2,480,958,722	2,494,571,435	2,526,487,573
Uplift (€)	0	335,272,879	337,828,778	351,441,491	383,357,628
TWA SMP (€)	53.37	61.65	61.67	61.82	62.30

3.4   Implications of Modelling

The RAs consider that 'spurious' price spikes that were perceived during the AIP/SEM/230/06 modelling process can, in the main, be attributed to (i) plant coming on for short periods of time (or for a longer period at low levels of output); or (ii) the manner in which the algorithm pursued the 'revenue objective', which tended to load uplift into short periods.

Following the conclusion of the additional modelling exercise, and having regard to the profile of SMP on individual days, the Regulatory Authorities now consider that setting α to zero and β to 1 (with a resulting CUW of zero) provides a superior daily SMP profile, at limited additional cost to the market.   The Regulatory Authorities also recommend setting δ to 5, on the basis that this is a positive number chosen to be large enough that the relevant constraint does not bind.

Algebraically, the effect of these parameter adjustments is to remove the first term of the uplift optimisation[3] (which sought to minimise SMP revenue) and to rely entirely on what was the second term of the uplift optimisation (which seeks to minimise the sum of the square of the uplift). Generator units are still required to recover their scheduled operating costs from within the SMP schedule.

It is noted that the minimisation of the second term alone will favour values of uplift which are (i) flat (as opposed to "spiky") across any given day; and (ii) low. As a consequence, even if reduced to this single term, the uplift optimisation will still contribute to meeting both the "cost" and "profile" objectives, as these were described in AIP/SEM/230/06.

3.5   Final Objectives

These revised parameter values are believed to better meet the set of objectives that the Regulatory Authorities have determined will apply to the calculation of uplift. These objectives, which were set out in AIP/SEM/142/06, are:

"FINAL OBJECTIVES

Global Objective

To set the cost of energy in the SEM to reflect the marginal cost of producing or consuming electricity during the optimisation time horizon.

Constraint

Generators' incurred costs within the market schedule during a period of continuous operation should be recovered through SMP within that period of operation.

Objectives

1. energy prices should be reflective of underlying market dynamics; consequently the recovery of start up and no load costs through SMP should not deviate significantly from the shadow prices.

2. the revenue paid through uplift revenues should be minimised."

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[3] The objective function of Option D, as set out in AIP/SEM/60/06, is:

$$\text{Minimise } \alpha \sum_{u=1}^{N} \left(\sum_{h=1}^{46,48,50} SMP_h * MSQ_{uh} \right) + \beta \sum_{h=1}^{46,48,50} \left(SMP_h - SP_h \right)^2 \text{ by changing the } SMP_h$$

The newly recommended set of parameters would lead to a small increase in overall projected SMP revenue and a rather more stable set of price profiles with a lower incidence of price spikes, compared to the parameter values that were proposed in AIP/SEM/230/06. The constraint of recovering scheduled operating costs from within SMP is still met.

The Regulatory Authorities consider, on the basis of the result of the most recent modelling exercise, that using the new proposed uplift parameter values will increase the degree to which objective 1 (minimising deviation from the shadow prices) can be met, with little negative impact on the degree to which objective 2 (minimising uplift payments) can be met.

The anticipated reduction in the incidence of price spikes is considered to better meet the global objective (that the cost of energy reflects the marginal cost) than was the case with the parameter values as previously proposed.

4. DECISION OF THE REGULATORY AUTHORITIES

Based on the analysis described herein and in AIP/SEM/230/06, and the responses to AIP/SEM/230/06, the Regulatory Authorities have decided in relation to the implementation of the uplift algorithm in the SEM to:

(a)   use Option D as per AIP/SEM/60/06;

(b)   set α to zero and β to 1 (with a resulting CUW of zero); and

(c)   set δ to 5.

While the Regulatory Authorities consider that it is appropriate to assign a zero weight to the parameter that was described in AIP/SEM/230/06 as implementing the revenue minimisation objective, the minimisation of uplift revenue remains an important objective that continues to be pursued using the new parameter values.

The Regulatory Authorities intend to monitor the effectiveness of the proposed Uplift Methodology, including the parameter values set out in this document, both in the context of the desired objectives and having regard to the stability of SEM prices. In particular, the Regulatory Authorities note that while the profile objective has been prioritised in this instance, the cost minimisation objective may be revisited in light of market data.

ENDS