Validation of the Market Simulation Model and Input Data for Market Power Mitigation in the SEM

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Table of Contents

Table of Contents

Management Summary

The Commission for Energy Regulation and the Northern Ireland Authority for Utility Regulation (the Regulatory Authorities or RAs) have developed a single all-island electricity market (the Single Electricity Market - SEM) which came into operation on November 1st 2007.

The RAs require modelling and statistical analysis in order to validate the current market simulation model used by the RAs, Energy Exemplar's PLEXOS for Power Systems, and to establish the suite of Directed Contracts required to meet the objectives of their market power mitigation strategy, for the third year of the SEM (October 2009 to September 2010). To implement this validation and to determine the Directed Contracts, the RAs require technical experts to deliver this assessment in a thorough and independent manner.

The project comprises three tasks:

1. Validation of the PLEXOS input data for the period October 1 2009 to September 30 2010;

2. Calibration of the PLEXOS results against actual SEM market outcomes for the period 1 April 2008 through to 31 March 2009; and

3. Provision of modelling and statistical analysis in order to establish the suite of Directed Contracts required to meet the objectives of the market power mitigation strategy for the third year of the SEM (1 Oct 2009 to 30 September 2010).

This report details KEMA's work in relation to the first two of the above activities. KEMA's conclusions in respect of these activities can be summarised as follows:

Validation of PLEXOS input data for the period 1 October 2009 to 30 September 2010: A detailed review exercise has been undertaken and the input data for the PLEXOS model have been verified. Fuel price data was revised to reflect the current forward market conditions. In general, no major issues were raised from updated generator and other model input data and all substantive changes to generator data were supported by acceptable rationale.

Backcast modelling for the period 1 April 2008 through 31 March 2009: Calibration of the SEM PLEXOS model was performed using actual load, actual generator availability and actual commercial offers for all units. Such actual data were provided by the SEM Market Monitoring Unit (MMU). KEMA conclude that PLEXOS produces a daily SMP pattern that is

largely consistent with that presented in the actual market. It was observed that the version of heuristic unit commitment chosen for this exercise provided a very reasonable fit to prices over the period examined but that it over-commits plant during peak periods which tends to drive an under-estimate of shadow price but an over-estimate of uplift. However, these differences tend to cancel each other out and over the 12 month period the performance of the model was very satisfactory. With the emergence of PLEXOS 5 it is suggested that for the next modelling round time is given to permit a comparison with the PLEXOS full integer unit commitment, and current versions of the heuristic commitment algorithm.

1. Introduction

As part of their market power mitigation strategy, the Regulatory Authorities (the RAs - the Commission for Energy Regulation and the Northern Ireland Authority for Utility Regulation) require modelling and statistical analysis to be undertaken on an annual basis in order to validate the market simulation model used by the RAs - Energy Exemplar's PLEXOS for Power Systems (Version 4.9 released in 2006). The validation of the market simulation model and, crucially, the inputs to the model was first undertaken by KEMA in 2007 prior to the implementation of the Single Electricity Market (SEM) so that the resulting model and input data could be employed by the RAs to establish the suite of Directed Contracts for the period 1 November 2007 to 30 September 2008 required to meet the RA objectives in relation to the mitigation of market power. This same work scope was repeated in 2008 by the National Economics Research Associates (NERA), covering the period 1 October 2008 to 30 September 2009.

For this third year of the SEM operation (1 October 2009 to 30 September 2010), KEMA were again asked to validate the market model and associated input data. Further for this year KEMA were asked to assist in the establishment of the prices associated with the suite of Directed Contracts for the third SEM year of operation.

To implement this validation and to determine the Directed Contracts, the RAs required KEMA to deliver this assessment in a thorough and independent manner.

The project comprised three tasks:

1. Validation of the PLEXOS input data for the period 1 October 2009 to 30 September 2010;

2. Calibration of the PLEXOS results against actual SEM market outcomes for the period 1 April 2008 through 31 March 2009; and

3. Provision of modelling and statistical analysis in order to establish the suite of Directed Contracts required to meet the objectives of the market power mitigation strategy for the third year of the SEM (1 October 2009 to 30 September 2010).

This report details KEMA's work in relation to the first two of the above activities. The structure of this report is as follows:

- Section 2 addresses the approach, scope and results of the validation of the input data to be used for the so called Validation Model (used to forecast System Marginal

Prices (SMPs) and, linked through the regression model, to so determine prices for the Directed Contracts);

- Section 3 describes the approach to calibrating the market model itself through the so called backcasting exercise;
- Section 4 presents KEMA's final observations (a number of observations and recommendations being contained throughout the course of the document); and
- Appendix A provides a comparison of the weekly SMPs produced by the validated (backcast) model and the actual prices established through the SEM for the period 1 April 2008 to 31 March 2009 for five sample months (April, August, October & December 2008 and March 2009).

The validated input data (subject to the removal of data deemed confidential by market participants), relevant fuel input data, backcast model and the validation model have already been published by the RAs on the AIP website.

2. Validation of Input Data for the "Validation Model"

KEMA developed a validated PLEXOS input database for 2009/10, where 2009/10 for the purposes of this Report comprises the last quarter of 2009 and the first three quarters of the calendar year 2010. The validated database includes:

1. Generator technical data by unit, including heat rates and technical constraints;
2. Generator VOM cost data;
3. Generator forced outage rates and planned outage schedules;
4. Generator loss factors;
5. Pumped storage reservoir limits;
6. Half hourly load and wind output forecast assumptions;
7. Embedded generation forecasts;
8. Forecast monthly hydro generation;
9. Variable cost input forecasts, including fuel and carbon costs at the station gate, using published fuel prices and transportation indices;
10. Load, technical and variable cost data for the GB market, to the extent necessary to enable modelling of the BETTA market to establish flows across the Moyle interconnector; and
11. New entrant Generator Units, capacity reductions and decommissionings, both committed and prospective, that will or are expected to enter and exit the market before the end of the study period.

KEMA engaged in three simultaneous processes to acquire the above information:

1. Contact with generation companies;
2. Contact with the Market Operator; and

3. Contact with ESB Power Generation (ESBPG) and with NIE Power Procurement Business (PPB) for fuel transportation adders.

The following describes the approach for obtaining and validating the above data in relation to each of these processes. The results are described within each of the relevant sub-sections below with the detailed dataset (excluding Variable Operating & Maintenance (VOM) costs and generation outage schedules as these have again been considered confidential in nature by market participants) having been published by the RAs on the AIP website.

2.1 Contact with Generators

KEMA sent an initial email to each generation company on 11-Feb-2009 to:

1. Describe to the generators KEMA's role in the validation process;
2. Request any and all updates to the NERA-validated database from last year, including updates that have not yet taken effect but will by the end of 2009/10;
3. Ask for explanations of any differences between:
    - 2009/10 submissions to KEMA and last year's submissions to NERA for 2008/09; and
    - 2009/10 submissions to KEMA and actual submissions to market during 2008/09.

The generator data that KEMA sought to validate consisted of the following items that feed into PLEXOS:

- Min Stable Generation;
- Max capacity;
- No Load Heat Requirement;
- Heat rate curve;
- Forced Outage Rate;
- Mean Time to Repair;

- Ramp Rate Up;
- Ramp Rate Down;
- Min Up Time;
- Min Down Time;
- Start up Energy (Hot, Warm, and Cold);
- Boundary times between start states; and
- VOMs (both Euros/start and Euros/MWh).

Whilst some generation companies stated that their data from 2008/09 still applied, most generators indicated a limited number of changes to some of the parameters. The majority of changes observed by KEMA from the generator submissions were in relation to VOMs.

KEMA reviewed generator returns and sought explanations from the generators for:

1. Changes of substantive magnitude in comparison with 2008/09 data submissions; and
2. Other aspects of interest or apparent anomaly.

This led to an iterative dialogue with a subset of generators. In nearly all cases, acceptable supporting rationale and/or evidence was provided by the generators. In the remaining cases KEMA, in discussion with the RAs, accepted the data as providing the "best available" view. In some instances, relating to new plant, the relevant generators concerned made refinements in the light of evolving information and through their discussions with KEMA and re-submitted the data for use by KEMA.

The following sub-sections set out the results of the validation in relation to each of the above data items. Data associated with existing generation plant (i.e. those already operating in the SEM) is considered first. A specific sub-section is provided in relation to Kilroot overburn which is a special application of VOM cost data relating to the unique (in the SEM) properties of Kilroot units. The final sub-section considers the technical and VOM cost data in relation to new generating plant planned to be commissioned into the SEM over the period ending 30 September 2010. Thus the following sub-sections address:

- Technical Performance data for existing plant;

- VOM cost data for existing plant;
- Kilroot overburn; and
- The technical and VOM cost data for new generating plant.

2.1.1 Validation of Existing Generator Technical Performance Data

2.1.1.1 Overview

KEMA compared the technical characteristics submitted by the generators for this years validation exercise (in response to the aforementioned KEMA request) with last year's validated dataset and the actual technical data offered by the generators to the market. KEMA identified instances where the submitted data were different from either last year's validated database or the generators' technical offers. In line with its approach highlighted above, KEMA queried the generators on observed substantial changes/differences and any other apparent generator data issues, seeking clarification or explanations.

For most existing generators the technical parameters remained the same or exhibited marginal differences. Key examples of material data changes by generators were:

- Coolkeeragh CCGT: change in structure of No Load Heat Requirement and Heat Rate "curve" (lower No Load Heat Requirement; higher Heat Rate);
- Erne: changes in Forced Outage Rates for Units 3 and 4 (one up; one down);
- Lough Rea: reduction in Forced Outage Rate; increase in Hot-to-Warm Boundary Time;
- Moneypoint: reduction in Ramp Rate for all Units;
- Marina: reduction in Forced Outage Rate; reduction in Minimum Stable Generation, Minimum Up and Down Times; and increase in Warm-to-Cold Boundary Time;
- Northwall GT: increases in Hot-to-Warm and Warm-to-Cold Boundary Times;
- Poolbeg CCGT: Reduction in Start Up Energy (Hot, Warm and Cold); change in structure of No Load Heat Requirement and Heat Rate "curve" (lower No Load Heat Requirement; higher Heat Rate);
- Turlough Hill: changes (mostly reductions) in Forced Outage Rates for all Units;

- West Offaly: increase in Forced Outage Rate;
- Ballylumford (Units 10, 31, 32 & 4); increases in Forced Outage Rates; and
- Huntstown 1 and 2: reduction in Forced Outage Rate for both stations.

In the majority of cases a satisfactory explanation was provided by the relevant generator giving KEMA reassurance that the generators' submission could be used. For the remaining cases KEMA discussed the information with the RAs and confirmed the data was the best available in respect of the plant. For example, in some cases it was observed that generators changed the data to reflect changing operating patterns during 2008/09 and its impact on aspects of technical performance.

The following sub-sections address each of the technical performance characteristics in turn.

2.1.1.2 Min Stable Gen, Max Capacity, Ramp Rates, and Min Times Up and Down

There were very few changes for these data items against the values submitted for 2008/09. This is to be expected as one would not expect technical performance in these aspects to change substantially year on year.

The two exceptions, as evident from above were:

- Moneypoint; where the Ramp Rates for all units reduced materially due the anticipated impact of new abatement plant; and
- Marina; where the Minimum Stable Generation was revised to meet Grid Code requirements and Minimum Up and Down Times were reduced to reflect that the unit is being converted from a combined cycle gas turbine to an open cycle gas turbine.

Other points to highlight are that, as in previous years:

(i) KEMA did not include dwell times in determining its consensus ramp rate;

(ii) Summer capacity ratings for CCGTs were set by derating winter capacity by 3% - CCGTs summer-winter ratings were set with PLEXOS's generator rating property; and

(iii) Run-up rates to Minimum Stable Generation were not modelled in the forecast, allowing generators to block load at min stable generation, as was the case with last year's validated model.

2.1.1.3 Validation of Heat Rate Curves

As in previous years, KEMA requested monotonically increasing heat rate curves with no more than four incremental heat rate slopes and a no-load heat requirement. Also as in previous years, KEMA requested heat rates to be provided on a Low Heating Value (LHV) basis.

In general heat rate curves were similar if not identical to the curves in NERA's validated dataset. Those changes that were presented were within a reasonable range. KEMA asked the generators with the largest heat rate changes to explain those changes. These were:

- Coolkeeragh CCGT; and
- Poolbeg CCGT.

In both cases, heat rates were adjusted this year to be in line with the actual operating performance rather than the previous data which was based on best information and the judgement of the generators.

2.1.1.4 Start Up Energy

Most units did not update their start energy from the values validated for 2008/09 and the only material change (a large reduction) was seen for:

- Poolbeg CCGT

In this case, start energy was adjusted to reflect actual operating performance rather than the best available information which had been employed last year.

2.1.1.5 Boundary Times between Start States

Similar to last year a number of generators updated their boundary times after technical reviews of their units' performance during 2008/09, and/or seeking to ensure they were in line with the Grid Code. The most material changes in this respect were for:

- Lough Rea; and
- Northwall GT.

A further material change was required in respect of:

- Marina

This was again to reflect its change from a combined cycle gas turbine to an open cycle gas turbine.

2.1.1.6 Forced Outage Rate and Mean Time to Repair

A number of generators made changes of varying materiality to their projected Forced Outage Rates (FOR) for 2009/10. When generators submitted updated FORs that differed from their validated values for 2008/09, KEMA asked the generators to explain why the changes had occurred and reviewed the reasonableness of the changes and of the explanations. Units which materially changed their Forced Outage Rate expectations were:

- Erne (Units 3 and 4);
- Lough Rea;
- Marina;
- Turlough Hill (Units 1-4);
- West Offaly;
- Ballylumford (Units, 10, 31, 32 and 4); and
- Huntstown 1 and 2.

2.1.2 Validation of Existing Generators' VOM Cost Data (Euro/Start and Euro/MWh)

Variable Operating & Maintenance (VOM) costs reflect the costs incurred by generators from their operating patterns due to wear and tear. These costs typically reflect the structure of O&M contracts that the generators hold with the turnkey contractors and consist of VOM costs relating to:

- The number of starts a generator undertakes (Starts); and
- The operation and maintenance costs associated with energy production (MWh).

This was the area of data where KEMA saw the greatest magnitude of changes in some generator submissions for 2009/10 versus those validated for 2008/09. This covered changes to both Start Up related and MWh output related VOM Costs. To date, VOM Costs have been deemed to be commercially confidential and as such have been reviewed and discussed by KEMA as necessary with generators on a bilaterally confidential basis. Thus

details of which generators and Units, to what extent they changed and the detailed reasons provided are not provided in this report. However the following sub-sections briefly consider each of Start Up VOM Costs and MWh Output related VOM Costs and gives some high level insights into the changes observed.

2.1.2.1 Start Up VOM Cost Data (Euro/Start)

For simplicity a single Start Up VOM Cost is used as previously adopted for PLEXOS modelling.

A small number of generators submitted proposed changes to their Start Up VOM Cost. Some of these were material and KEMA specifically sought the supporting rationale/explanation and where possible some evidence to support such changes. Whilst, as indicated above, KEMA cannot divulge specific details of these costs and the dialogue KEMA had with various generators, it is possible to indicate that KEMA found all of the supporting rationale, explanation, and in some cases evidence, for the changes were well founded on either a technical or commercial basis. At a high level three drivers for changes were cited by more than one generator. These were:

- Impact of changes in operating patterns in 2008/09 from that envisaged when agreeing 2008/09 validated data in 2008;
- Connected to or separate to this, anticipated changes in operating patterns for 2009/10 versus 2008/09 due to the entry of new generation capacity in 2009/10 (Aghada and Whitegate CCGTs); and
- Impact of changes in the economic climate impacting on relevant costs of O&M, e.g. change in Exchange Rates.

2.1.2.2 Output VOM Cost Data (Euro/MWh)

As for Start Up related VOM Costs, a small number of generators also submitted proposed changes to their Output VOM Costs. Again, some of these were material and KEMA specifically sought the supporting rationale/explanation and where possible evidence of such changes. Without divulging specific details of these costs and the dialogue KEMA had with various generators, it is possible to indicate that KEMA found all of the supporting rationale, explanation, and in some cases evidence, for the changes were well founded on either a technical or commercial basis. At a high level the same three drivers as highlighted for changes to Start Up related VOM Costs were also cited as driving changes to Output related VOM Costs by more than one generator.

2.1.3 Kilroot Overburn

Kilroot Coal units have a coal overburn and an oil overburn mode which allows for additional MW above the MW level possible in their “regular” coal burn mode. Last year NERA modelled Kilroot as an all coal unit and captured its overburn modes through a VOM that initiates at the MW levels where Kilroot’s coal and oil overburn regions begin. KEMA kept the same settings this year, inputting in PLEXOS the Generator “Mark-up” property for both Kilroot Coal units. The mark-up property values validated by KEMA are not included in the public version of the PLEXOS database because of the confidential nature of those values.

2.1.4 Validation of New Entrant Generators’ Data

Unlike last year, a key aspect for the generator data validation exercise was the capture, review and determination of the generator data values for both technical performance parameters and VOM Costs for new entrant generation due to commission within 2009/10. These generators were:

- Aghada CCGT (due to commission Q4 2009);
- Whitegate (Bord Gais) CCGT (due to commission Q2/3 2010); and
- Kilroot GT3 and GT4 (due to commission in Q1 2009).

As is to be expected, setting technical performance data and even VOM Costs data ex-ante of operating experience can be relatively subjective, particularly where new or refined types of technologies of plant are being commissioned.

For Kilroot GT3 and GT4, the validation exercise was relatively easy as they are essentially identical generating units to the existing Kilroot GTs 1 & 2. Consequently KEMA accepted Kilroot’s submission of identical performance and VOM Costs data for these new units.

For both the Aghada and Whitegate CCGTs, setting the generator data for both technical performance and VOM Costs was more challenging. This was due to the use of the latest CCGT technology and thus a lack of like for like comparators. Nonetheless, KEMA reviewed the relevant data submissions in the context of (a) understanding of the technology and configuration of the CCGTs; (b) comparison of technical performance and VOM Costs parameters for existing CCGTs in Ireland; (c) expectation of plant performance based on use

of such technology elsewhere internationally; and (d) the evidence, provided by the two CCGTs, to support their data submissions.

In general, KEMA was satisfied that the data submitted for the Aghada and Whitegate CCGTs were reasonable. However there was some iteration on No Load Heat Requirements and Heat Rate values driving overall Thermal Efficiency performance. This reflected the particular difficulty of predicting these aspects of performance ex-ante (recognising manufacturers claims can often be proved to be optimistic), especially how the CCGTs might "bed in" in their first year; and evolving information available to the plant developers. Nonetheless, KEMA expected that these CCGTs should show greater Thermal Efficiency performance than the existing CCGTs. After some further dialogue on this basis, KEMA was able to set values for both Aghada and Whitegate which sees them set to be the most efficient plant in the SEM.

2.2 Contact with the Market Operator

The Market Operator was contacted via an initial email asking for updated information on:

- Half-hourly demand;
- Wind profiles and capacities;
- Outage schedules;
- Monthly hydro generation forecasts;
- Retirements, new units, deratings, and expansions;
- Embedded generation profile;
- Generator loss factors; and
- Pumped storage reservoir limits.

Data on each were received. The details in relation to each are presented below.

2.2.1 Half-hourly Demand

KEMA received forecasts for 2009/10 for Northern Ireland (NI) and the Republic of Ireland (ROI) from EirGrid (the ROI System Operator), which were combined into one SEM forecast.

The initial submission from EirGrid, presented a 2% increase in the demand for 2010 compared to 2009 data.

However, KEMA, taking into consideration the economic downturn of the past months, sought confirmation from EirGrid of when the forecast report was conducted and whether the recession conditions of the country were captured in the forecast. EirGrid indicated that the forecast preceded the strong economic downturn and came back with a revised forecast for the Republic of Ireland indicating that in light of the changed economic situation the demand for electricity is expected to change from the original prediction.

However, EirGrid do not expect a 1:1 correlation in energy demand and economic activity in the downturn. The precise relationship is affected by factors such as economy wide structural changes – the effect of reduction and rebalancing of employment in manufacturing, construction and services – and the rate of household formation, particularly as a result of emigration. The combined effect of these factors is difficult to forecast. While they have reasonably robust relationships between economic activity and energy consumption when economic activity is increasing, there is limited experience as to how well those relationships will hold in the downturn.

2.2.1.1 Republic of Ireland

For the Republic of Ireland, there was a 2.2% growth (1.9% when adjusted for the leap day) in exported energy from 2007 to 2008 largely in the beginning of the year; however, most recent economic commentaries forecast contraction in the Republic of Ireland economy in 2009 of between 1.75 and 3.6% in consumption and between 2.5 and 3.9% in GDP. Based on these figures and initial outturn demand data for 2009, EirGrid consider that the best estimate for 2009 demand is a contraction of approx 2% back to 2007 levels. Beyond 2009, they assume that 2010 demand will grow by 2% back to 2008 levels.

The initial forecast KEMA received was based on year on year growth of 2.1% from 2007. To account for the expected contraction in 2009, EirGrid proposed that the Republic of Ireland half hourly figures for 2009 and 2010 should be multiplied by a factor of 0.96. This brings them to approximately the 2007 and 2008 levels respectively, which EirGrid considers would better reflect the expected circumstances in 2009 and 2010. Hence 0.96 was taken as a 'correction factor' to align the demand forecast with the changed economic climate.

KEMA took into consideration EirGrid's remarks and updated the forecasts and adjusted the load files accordingly.

2.2.1.2 Northern Ireland

Regarding the demand forecast for Northern Ireland, EirGrid identified a comparatively moderate growth over the last decade, relative dependence on public expenditure and growth of cross-border shopping volumes meaning that the NI economy will be less severely affected by the recession than the Republic of Ireland.

Most recent economic analyses forecast growth of 1% in consumption and a contraction of 0.5% in GDP. This implies that the year on year growth from 2007 of 1% as outlined in the Seven Year Statement is still valid. Hence the Northern Ireland demand forecast data was not adjusted.

2.2.2 Wind Profiles and Capacities

The three regional wind time series for the Republic of Ireland (A, B & C) and the one for Northern Ireland utilised in the forecasting process are based on 2007 wind output data for each region. This differs from last year where Northern Ireland was profiled in line with Region A of the Republic of Ireland. The change gives greater accuracy of wind modelling within PLEXOS. The output of wind generation is determined by scaling the capacity in each region (provided by the Market Operator) by the relevant wind time series value.

2.2.3 Outage Schedules

The Market Operator provided an updated outage schedule for each unit in the SEM as well as for Moyle. The schedule was checked for reasonableness against the schedule used in last year's validated model. Where outage data were missing or unclear – or where there were unexpected and large changes from last year's schedule – the Market Operator was queried to confirm or provide more up-to-date information. Any updates were incorporated.

2.2.4 Hydro Generation Forecasts

Generation constraints were set within PLEXOS for each month based on historical metered data for 2008. These were single value daily constraints applicable for each month in the study period. For the purposes of the forecast (Validation), PLEXOS was then to be allowed to schedule hydro generation within these constraints and the other associated technical parameters (and scheduled outages etc.).

2.2.5 Retirements, New Units, Deratings, and Expansions

The Market Operator provided information on unit retirements and deratings, which were accepted. The list of units being decommissioned and new units coming online is as follows:

Table 1-1: Plant Updates

Plant Status	Plant Name	Date In/Out	Comments
New	Aghada CCGT	01/11/2009	
New	Tawnaghmore Peaker 3	16/08/2008	Moved from Aghada
New	Bord Gais (Whitegate) CCGT	01/07/2010	
New	Kilroot GT3	01/03/2009	
New	Kilroot GT4	01/03/2009	
Retired	Aghada Peaker	16/08/2008	Moved to Tawnaghmore
Retired	Poolbeg 1	01/03/2010	
Retired	Poolbeg 2	01/03/2010	

As discussed in Section 2.1.4, KEMA focused extensive attention on new entrant generators and their associated technical performance.

2.2.6 Embedded Generation Profile

The Market Operator provided a typical embedded generation profile (hourly MWh for weekdays and weekends). The Republic of Ireland half-hourly demand data includes demand to be met by small scale generation (SSG) while the Northern Ireland half-hourly demand data does not include demand to be met by SSG. In order to ensure consistency within the model it was necessary to account for the SSGs in the Republic of Ireland by utilising a regional generation profile to represent the aggregate generation from SSGs. It

should be noted that embedded wind is not included in SSG but is included in the wind capacity figures. The profiles are based on historical patterns scaled to the expected installed capacity.

2.2.7 Generator Loss Factors

The Market Operator provided updated monthly day/night loss factors for each unit. The values for 2009 were taken from the information published under the Transmission Loss Adjustment Factor-2009 by the Market Operator. It was indicated to KEMA that values for 2010 will be published only by end of 2009. Thus in the absence of data for 2010, the 2009 values were assumed to apply for 2010 for the purpose of the PLEXOS modelling.

2.2.8 Pumped Storage Reservoir Limits

Both the maximum and minimum reservoir capacity was provided by the Market Operator which was accepted by KEMA and was used unchanged for the purpose of PLEXOS modelling.

2.3 Contact with ESBPG and NIE PPB for Fuel Transportation Adders

The method of modelling fuel costs in PLEXOS is unchanged from last year's model. The fuel prices input into PLEXOS represent all-in prices, inclusive of transportation to the plant and any relevant excise charges, taxes or port duties. Carbon costs are represented as a fuel tax in PLEXOS. The total fuel cost faced by the units in PLEXOS is the sum of the fuel price and the fuel tax.

KEMA contacted ESBPG and NIE PPB to update the fuel transportation costs.

The various price components are converted to all-in (commodity + transport) prices/GJ for entry into PLEXOS. Carbon prices are converted into Euros/GJ fuel "taxes" for PLEXOS based on fuel emissions and oxidization factors.

2.4 Confidentiality of Data

Last year, following extensive dialogue between the RAs and the generators, all data except for VOM costs and outage schedules were published in a generator database available on the AIP website. This year, the same indications of desire for confidentiality of VOM Costs

and outage schedules have been made by a number of generators in their correspondence with KEMA. Consequently it remains the case for the 2009/10 generator data that the Regulatory Authorities have published the validated generator data except for VOMs and outage schedules.

3. Calibration of PLEXOS (Backcasting)

In this task, KEMA calibrated PLEXOS against actual half hourly ex-post data consisting of shadow prices, uplift, and SMP as well as Market Schedule Quantities (MSQs) from the Market Operator for the period from 1 April 2008 to 31 March 2009. This exercise is known as "backcasting" and the resulting model is referred to as the "backcast model".

KEMA's starting point for the calibration process was the NERA backcast model from last year's exercise. The stages of this backcasting exercise were as follows:

- The first step was to update the model with the technical and commercial offer data by unit, as well as the half hourly ex-post demand data and autonomous/price taker generator outputs, provided by the SEM Market Monitoring Unit (MMU); and

- Sequentially review the underlying reasons for any differences between the output of the PLEXOS Backcast run and the actual SMP data provided by the MMU and make appropriate modifications to the model settings in order to eliminate all possible differences, rerun it and check once again the degree of calibration.

Similar to last year, the work focussed on identifying differences in SMP values and/or load quantities (MSQ).

3.1 PLEXOS 4.9 vs. PLEXOS 5

PLEXOS 4.9 is in common use by market participants in the SEM. PLEXOS 5 test versions were available during the time of this study and KEMA conducted some initial test comparisons between these versions of PLEXOS 5 and PLEXOS 4.9. The results of these tests were inconclusive and therefore, given the tight timescales for project delivery and in consultation with Energy Exemplar, it was decided to retain the use of PLEXOS 4.9 for this years analysis.

Energy Exemplar have stated that PLEXOS 5 offers significant performance improvements over PLEXOS 4.9, both in terms of runtime and quality of the unit commitment solution. Given this KEMA suggests the re-trial of PLEXOS 5 for future model validation by the RAs.

3.2 PLEXOS Model Settings

In conducting the PLEXOS calibration exercise KEMA conducted a number of assessments of different PLEXOS model settings that could be adopted. As a result of these model setting tests, KEMA determined that:

- A Rounded relaxation level of 5 was recommended, in line with last year's recommendations – a higher rounded relaxation tolerance (8) was also tested, but results presented no significant improvement;
- Whilst a Price Cap of €1000/MWh was generally used as adopted last year, a user could use €300/MWh with little difference in the results;
- The continued use of the MSL Filter is required - removal led to worsened performance in predicting Uplift;
- For modelling starts, we re-confirmed last year's observations that only warm start costs should be used (as opposed to hot, warm and cold). It was again observed that PLEXOS created particularly high uplift solutions when it started units unnecessarily from a cold-start case[1]. The use of warm starts only presents a significant improvement to the PLEXOS calibration (which can decrease PLEXOS SMP values by up to 10%);
- When entering offers directly (for the Backcast process), the PLEXOS model property Uplift Cost Basis needs to be set to Bid based – note that heat rates and fuel cost data are still required in relation to GB as bid/offer data is not available even for the Backcast for the GB market; and
- Use of the Mixed Integer Program (MIP) option can provide more accurate results, particularly for MSQs and for short time periods but run times are too long for practical use for more extended and/or repeat SEM modelling.

[1] Energy Exemplar claim that PLEXOS 5 models cold, warm, hot starts much more accurately but in the time available KEMA were unable to verify this.

3.3 Input Data for the Backcast Model

The main purpose of undertaking the backcast exercise is to validate and/or improve the quality of the forecasts from PLEXOS. The following sub-sections present the input data that were used in the backcast.

3.3.1 Demand

Half-hourly demand was updated using observed actual data provided by the MMU. This actual demand was defined as the sum of actual observed generation (excluding the load of pumped storage units) plus net Moyle imports adjusted for losses. This actual demand was then input into PLEXOS for each half hour and PLEXOS determined the quantity of pumped storage demand to add as part of the pumped storage optimisation process.

3.3.2 Commercial Offer Data

The following commercial offer data was provided by the MMU and entered directly into PLEXOS for the backcast:

- Price-quantity pairs;
- No-load offers; and
- Start offers –warm only.

3.3.3 Technical Offer Data

The following technical data was employed from last year's NERA Validation Model for the back-cast:

- Max capacity;
- Min Stable Generation;
- Ramp rates up and down; and
- Min times up and down.

In addition the half-hourly availability (with some exceptions, see sections below) was obtained from the MMU for the backcast. Actual half hourly availability was set via the generator rating property.

To be consistent with the forecast model, run-up rates were not modelled up to Minimum Stable Generation in the backcast, allowing generators to block load at min stable generation.

3.3.4 Outages

For the backcast, availability was not modelled with stochastic forced outages or planned outages. Rather, actual half-hourly availability of each generating unit was input directly from the offer data (see section 3.3.3 above).

3.3.5 Wind

Actual half-hourly wind production data was provided by the MMU and input into PLEXOS.

3.3.6 Hydro

An availability profile for each unit was input to PLEXOS using the Rating feature and this was linked to a monthly generation profile for each station (acting as a constraint). PLEXOS then scheduled the output for each hydro unit within these constraints.

3.3.7 Pumped Storage

Pumped storage efficiency factors and other technical parameters were left unchanged from the last year's process. For the purpose of the backcast PLEXOS was asked to optimally schedule pumping load and generation from pumped storage.

3.3.8 Peat

Peat has a minimum annual load factor target which must be achieved. For the backcast process, the Max Capacity Factors in annual and monthly basis were directly provided by the MMU and input in the model. With this property, PLEXOS schedules the production of peat so as to meet the minimum production requirements.

3.3.9 Moyle/Great Britain

Moyle flows were modelled using the 2007 approach of modelling a separate Great Britain region within PLEXOS, connected to the SEM by a constrained Moyle interface. The GB region was composed of a single node (BETTA) with 10 generating units, representing the

total generation capacity (divided by fuel type) of the BETTA market. The initial generation capacities for the backcast model across the different fuel types were as follows:

- 3 coal units, totalling almost 29000 MW;
- 4 gas units totalling almost 28000 MW;
- 1 non-Fossil unit of over 16000 MW;
- 1 oil unit of 2500 MW; and
- 1 distillate unit of 1000 MW.

Actual Great Britain load for the backcast period was obtained from the GB "BM reports" website and daily fuel prices were also employed to enable PLEXOS to strike an appropriate flow across the Moyle Interconnector.

For the purposes of the forecast (Validation) work, the BETTA demand profile was produced by rolling forward the 2009 forecast utilised by NERA last year to 2010 as an examination of the National Grid website showed little change in demand between 2009 and 2010, while on the generation side the BETTA backcast capacities were updated to reflect changes identified as due to occur through 2009 and 2010.

3.3.10 Actual Market Outcomes

A database was assembled of actual unit output in each half-hour trading period from 1 April 2008 to 31 March 2009, including Moyle flows and assumed Moyle losses. The actual Shadow Price, Uplift and SMP in each half-hour were included. An identically formatted parallel database was then prepared for the PLEXOS output from each of the backcast runs undertaken so that detailed comparative evaluations could be performed.

3.4 Backcasting Model Results

In this sub-section the main results from the backcast process are presented.

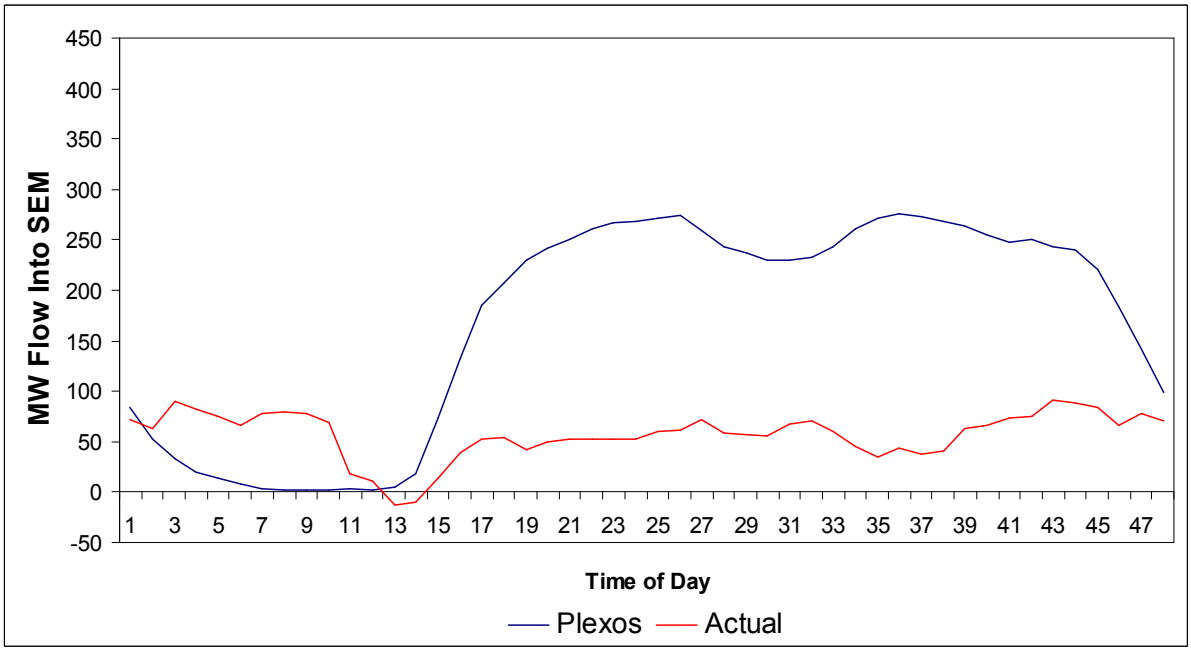
In summary, comparing the SMP values produced from the model with the actual market values KEMA concludes that PLEXOS produces a daily SMP pattern that is largely consistent with that observed in the actual market.

The following figures and tables present the results from the backcasting process where the period from 1 April 2008 to 31 March 2009 was examined. Further analysis on five selected months – April, August, October & December 2008 and March 2009 - was performed in order to examine the seasonal behaviour of the model.

3.4.1 Analysis of Moyle

KEMA analysed the pattern of the Moyle interconnector as it was predicted by PLEXOS and this is illustrated in Figure 3-1.

Figure 3-1: Moyle Comparison: April 2008-March 2009



The results are in line with last year's exercise and it is clearly demonstrated that in the actual market outcomes there is a lack of Moyle dynamic response to price arbitrage opportunities compared to the modelling results. PLEXOS treats Moyle in a much more responsive way towards changing market conditions than the actual market does. The differences are likely to be due to the subtleties of contractual issues, data for which is not available and therefore cannot be reflected into the PLEXOS modelling.

KEMA also investigated alternative treatments of the Moyle interconnector in order to reduce the responsiveness of Moyle (as a substitute for being able to model contractual positions/impacts). The following sub-sections address this work.

3.4.1.1 Actual Half-Hourly Flows

Actual interconnector flows, provided by the MMU for the period March to December 2008[2], were used as an input in the model. However, there was no improvement in the results and in fact the uplift issue was worsened. This can be attributed to the fact that without the flexibility of the interconnector flow (min and max flow), PLEXOS tends to present over-commitment.

3.4.1.2 Model Set-Up with One Region

To seek to reduce the arbitrage behaviour of PLEXOS, the model was re-set as one region (the Single Electricity Market) with two nodes – SEM and BETTA - and Moyle connecting the two.

The results showed a slight improvement in terms of SMP values and over-commitment issues. This may be because PLEXOS, in the case of two regions, tends to focus on the optimisation of the BETTA market, which is significantly bigger than the Irish one, failing to capture the market arrangements and the import needs of the island of Ireland.

Based on this analysis KEMA recommends further model testing is undertaken for the next backcast exercise in order to ascertain the complete impact of utilising a single region in the modelling of the SEM and BETTA. However it should be noted that employing a single region as tested may distort uplift values as BETTA generation may be included within the uplift calculation. This, as well as all other impacts, would need to be carefully examined and evaluated.

3.4.2 Analysis of Hydro and Pumped Storage Schedules

For the analysis of hydro, daily actual hydro generation provided by the MMU was compared with the PLEXOS output (derived as described above in section 3.3.6).

For pumped storage, the plant capacity and efficiency and reservoir capacities were put in the model and PLEXOS determined the pumped storage schedule.

[2] This period was selected as these tests were conducted early in the validation process, prior to later actual market data becoming available.

The resultant hydro and pumped storage profiles closely fit actual profiles (see Figure 3-2 and Figure 3-3 below), however this configuration exhibited a tendency to systematically under commit pumped storage.

Figure 3-2: Hydro Comparison: April 2008-March 2009

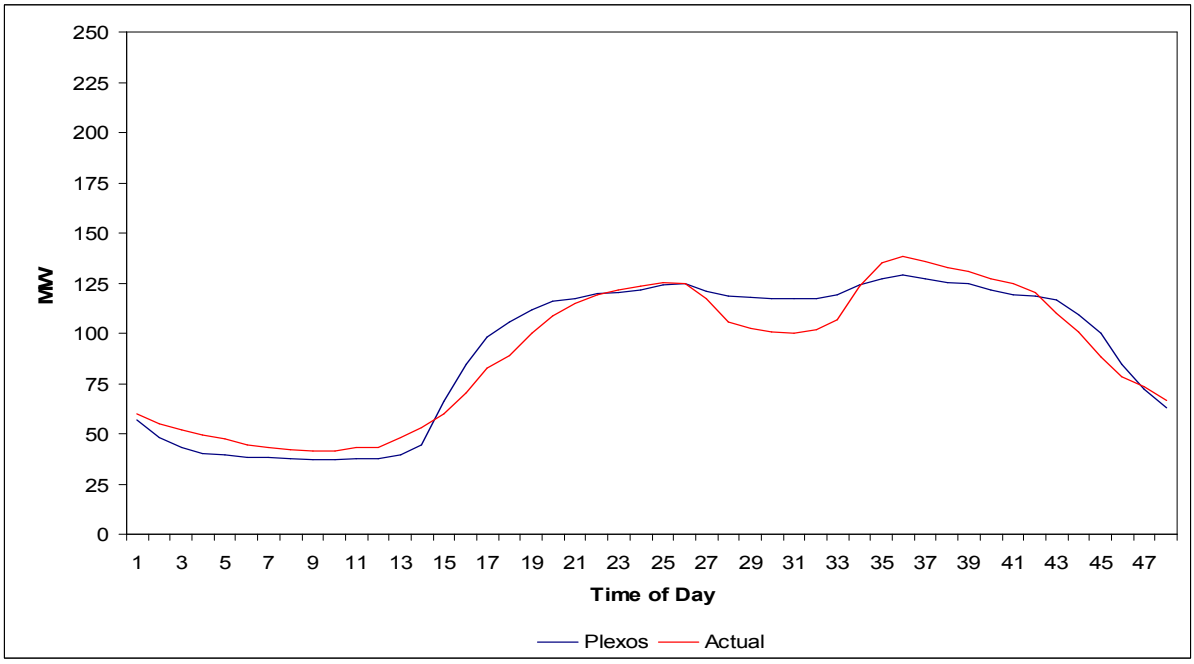
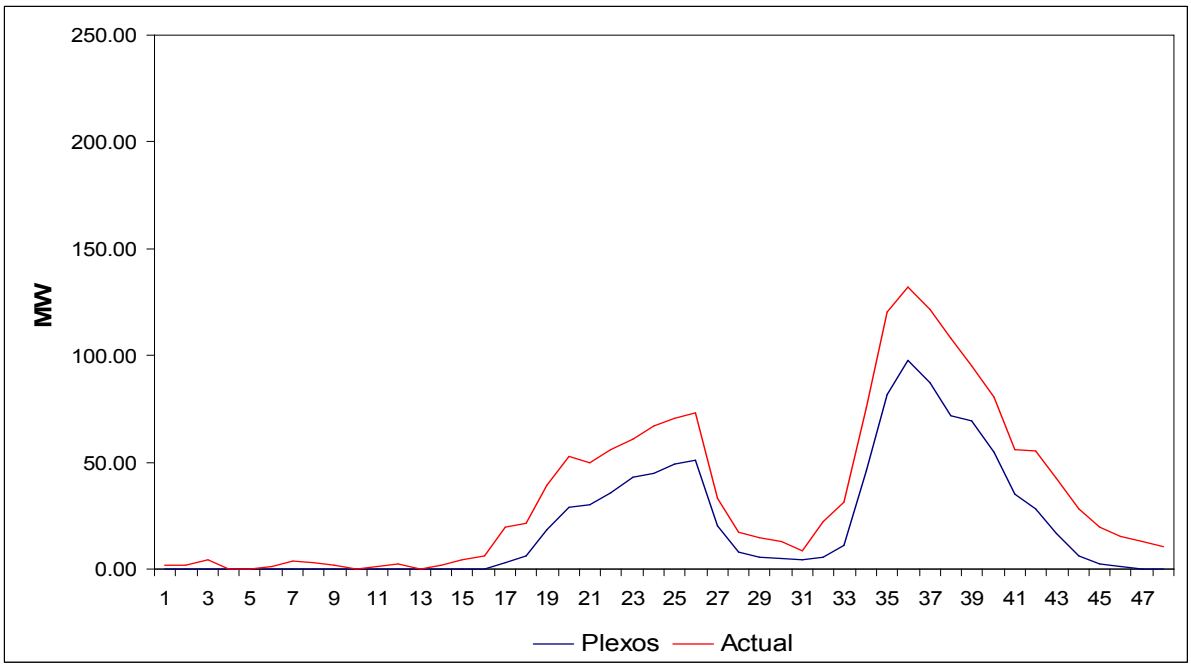


Figure 3-3: Pumped Storage Comparison: : April 2008-March 2009



3.4.3 Analysis of Shadow Prices and SMP

From the results of the KEMA modelling for April 2008 – March 2009 (as can be seen in the following figures), it can be seen that the shadow prices from PLEXOS reasonably closely match the outturn values. However, the SMP values from PLEXOS show a similar profile but are not as close in absolute value, especially at peak times.

Figure 3-4: Shadow Price and SMP Comparison: April 2008 - March 2009 (Actual)

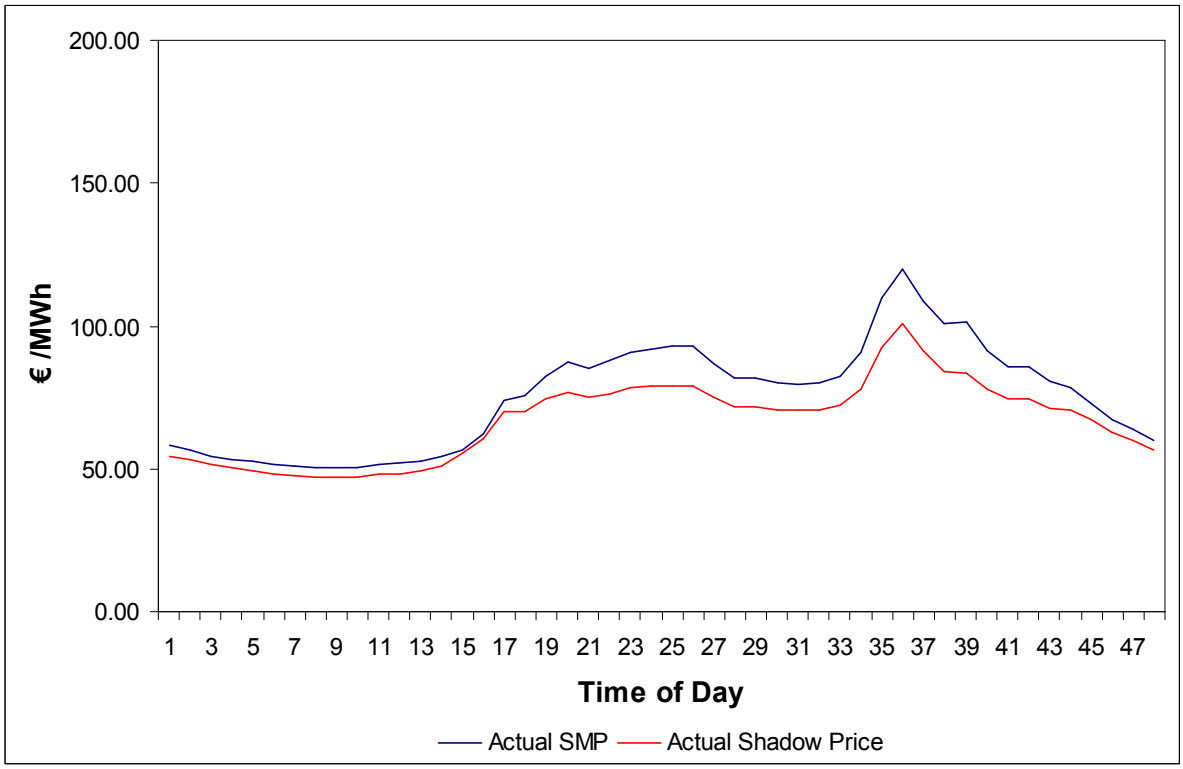
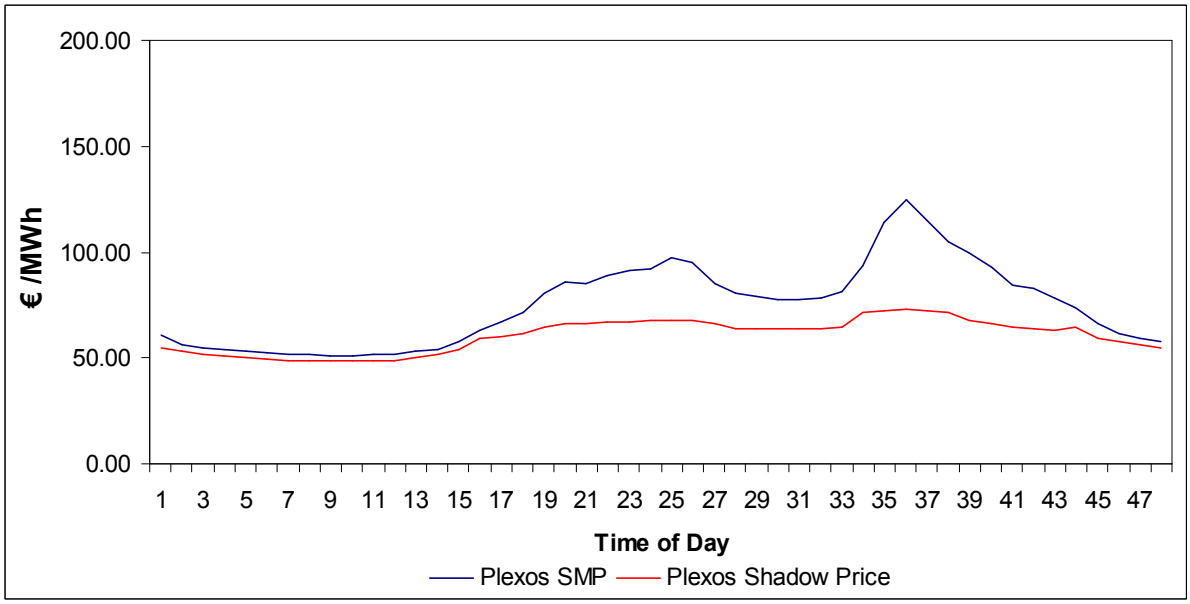


Figure 3-5: Shadow Price and SMP Comparison: April 2008 - March 2009 (PLEXOS)



A more detailed analysis of the SMPs (shown in the following figures) shows that the discrepancies that exist (which over the year relatively limited) are driven by consistent over-commitment of units by PLEXOS at peak hours. When asked, Energy Exemplar commented that this is a function of the simple rounding unit commitment heuristic chosen for this exercise[3]. The over-commitment by PLEXOS tends to drive an underestimate of shadow price but an overestimate of uplift and the two effects tend to offset each other.

Whilst April and October 2008 exhibited the greatest instances of over-commitment of units at peak times and thus over-estimation of SMP, this was not a consistent feature observed throughout the year as illustrated below:

[3] Energy Exemplar claim that the heuristic (Rounded Relaxation) and full integer commitment performance of PLEXOS 5 is greatly improved through the use of new commercial MIP solver engines.

Figure 3-6: SMP Comparison: April 2008

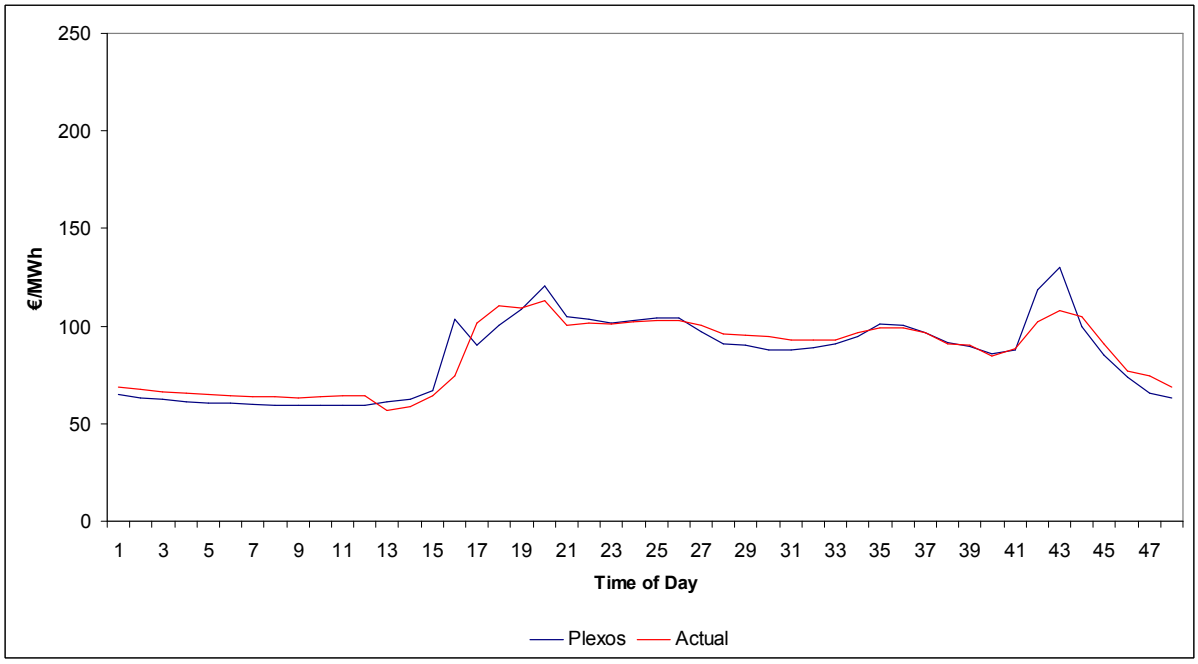


Figure 3-7: SMP Comparison: August 2008

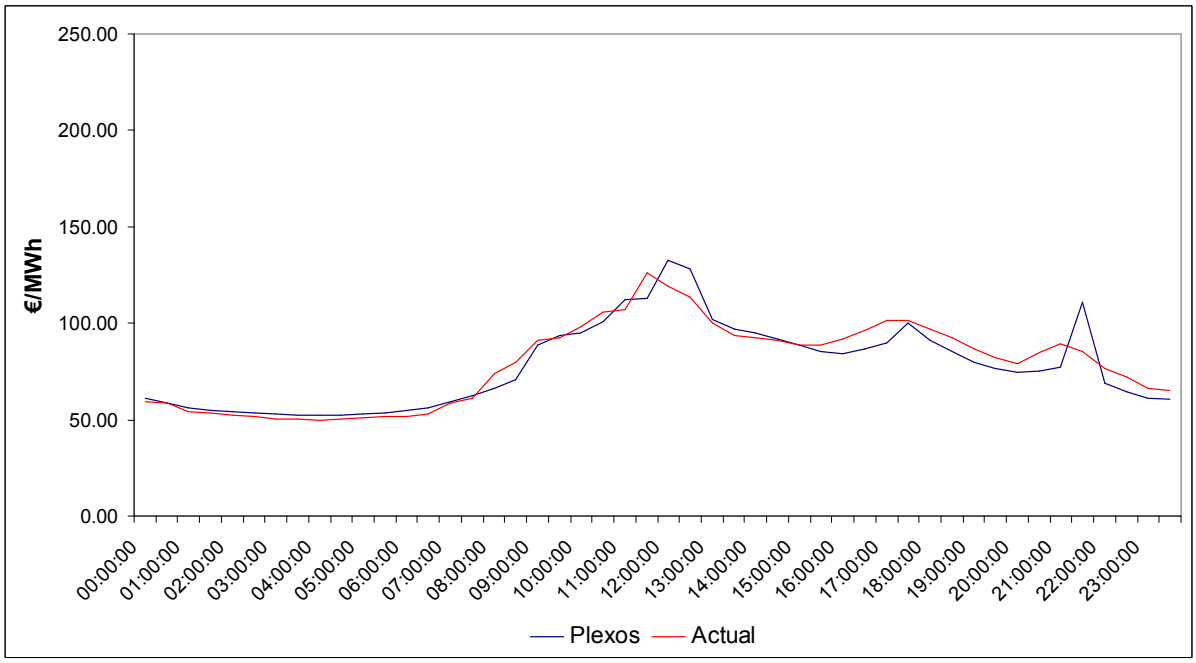


Figure 3-8: SMP Comparison: October 2008

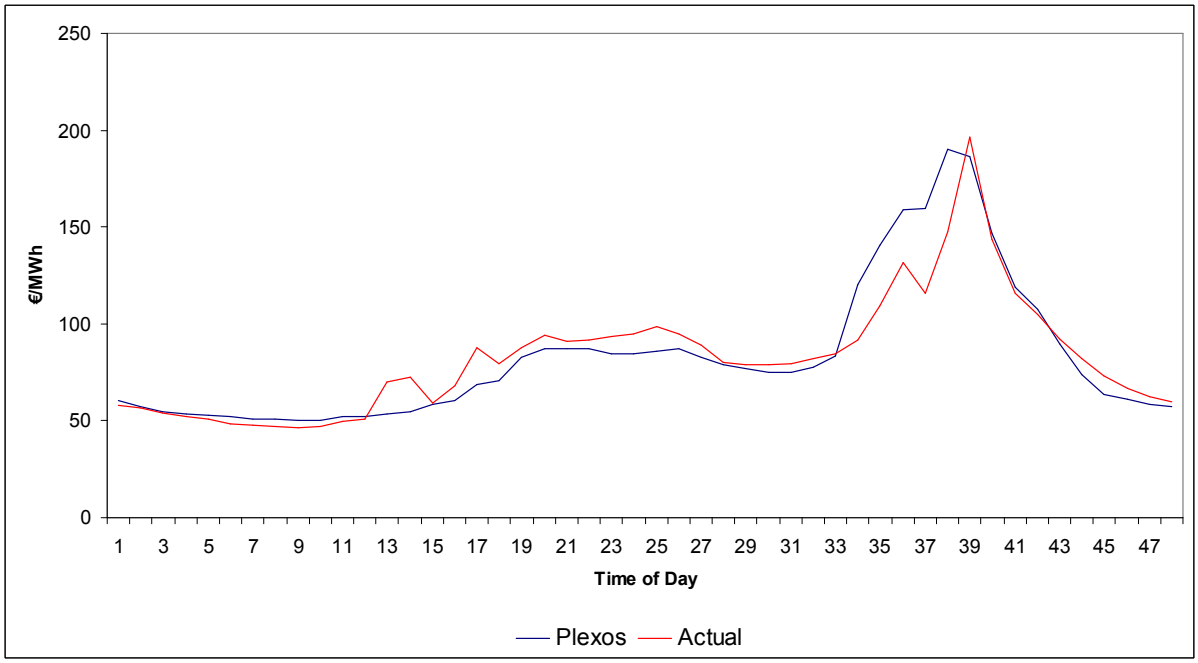


Figure 3-9: SMP Comparison: December 2008

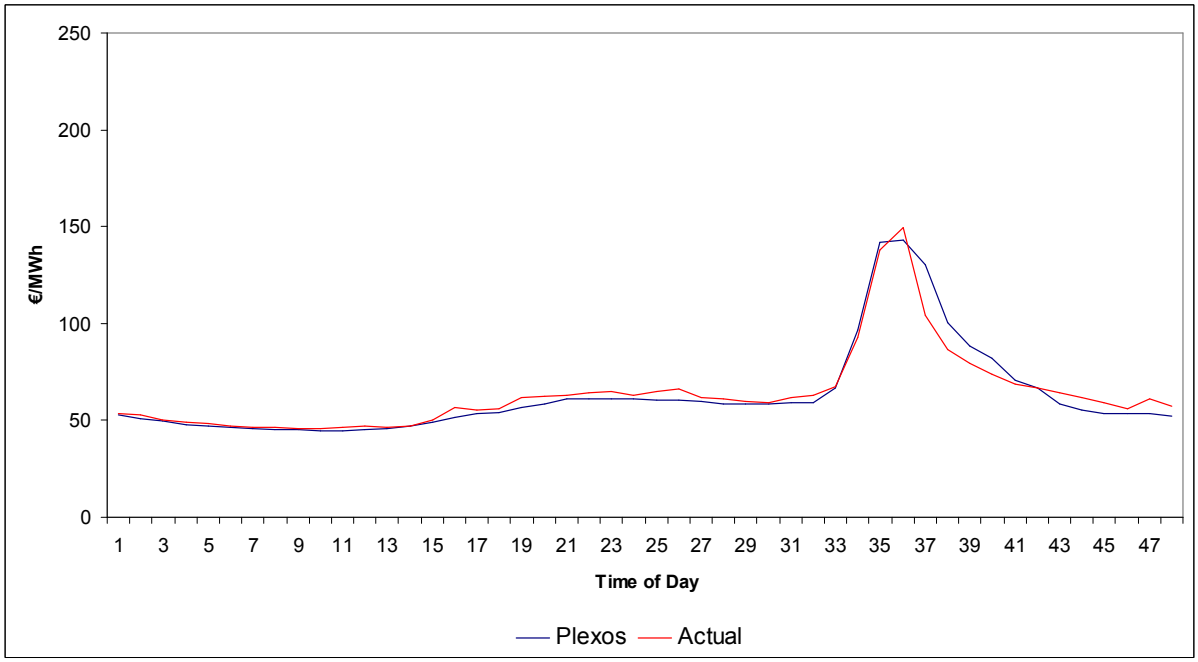
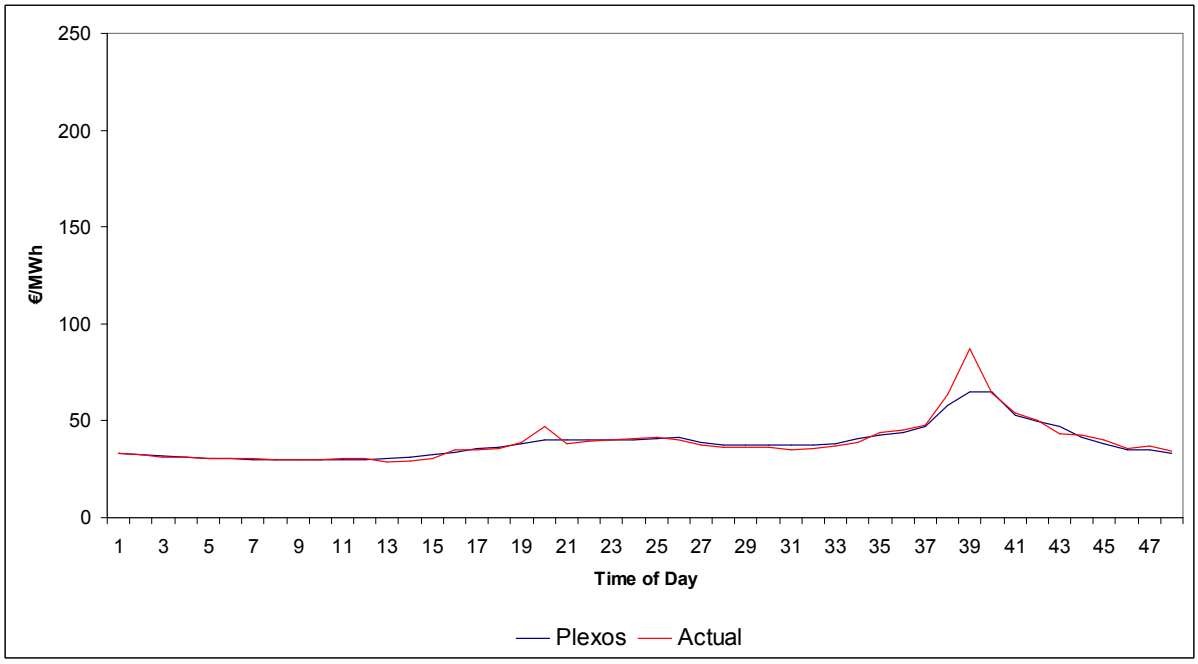
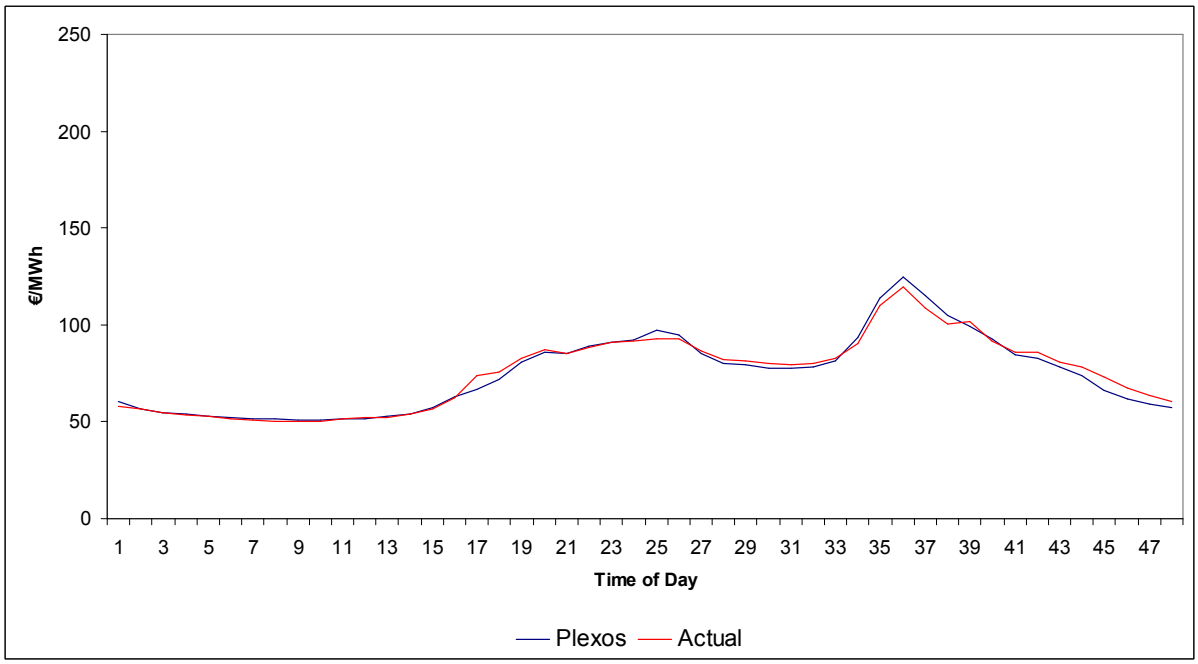


Figure 3-10: SMP Comparison: March 2009



For the whole year results, as can be seen in the figure below, the predictive performance was very satisfactory. Only minor differences can be observed with PLEXOS slightly over-committing units in peak periods and slightly under-committing units in mid-peak periods. However, throughout the year, the goodness-of-fit was very satisfactory.

Figure 3-11: SMP Comparison: April 2008 to March 2009



As can be seen in Table 3-1, the percentage difference between actual and PLEXOS modelled data was in the range of – 0.51% to 1.31 % for the whole period, although the goodness-of-fit was somewhat less satisfactory for individual months. We attribute this to the fact that time weighted average prices for the whole year eliminate significant differences that might occur in individual months through aggregation.

Table 3-1: SMP, Shadow Price and Uplift Comparison

	Base Prices April08 -March09			Mid Prices April08 - March09			Peak Prices April08 - March09		
	Sh. Price	Uplift	SMP	Sh. Price	Uplift	SMP	Sh. Price	Uplift	SMP
Actual	€ 66.96	€ 8.22	€ 75.18	€ 74.51	€ 10.64	€ 85.15	€ 83.54	€ 14.75	€ 98.29
PLEXOS	€ 60.46	€ 14.34	€ 74.80	€ 64.92	€ 19.50	€ 84.42	€ 68.26	€ 31.33	€ 99.58
Difference	-€ 6.50	€ 6.12	-€ 0.38	-€ 9.59	€ 8.86	-€ 0.73	-€ 15.29	€ 16.58	€ 1.29
% Difference	-9.71%	74.42%	-0.51%	-12.86%	83.20%	-0.86%	-18.30%	112.44%	1.31%
	Base Prices April 2008			**Mid Prices April 2008**			**Peak Prices April 2008**		
	Sh. Price	Uplift	SMP	Sh. Price	Uplift	SMP	Sh. Price	Uplift	SMP
Actual	€ 72.13	€ 13.66	€ 85.78	€ 79.36	€ 16.17	€ 95.53	€ 78.31	€ 17.17	€ 95.47
PLEXOS	€ 69.92	€ 15.12	€ 85.04	€ 74.53	€ 21.38	€ 95.91	€ 74.28	€ 26.00	€ 100.28
Difference	-€ 2.21	€ 1.46	-€ 0.75	-€ 4.83	€ 5.21	€ 0.38	-€ 4.03	€ 8.84	€ 4.81
% Difference	-3.06%	10.70%	-0.87%	-6.09%	32.22%	0.40%	-5.15%	51.49%	5.04%
	Base Prices August 2008			**Mid Prices August 2008**			**Peak Prices August 2008**		
	Sh. Price	Uplift	SMP	Sh. Price	Uplift	SMP	Sh. Price	Uplift	SMP
Actual	€ 71.35	€ 7.56	€ 78.91	€ 80.59	€ 9.87	€ 90.46	-	-	-
PLEXOS	€ 63.56	€ 14.27	€ 77.83	€ 68.91	€ 19.28	€ 88.19	-	-	-
Difference	-€ 7.79	€ 6.71	-€ 1.08	-€ 11.67	€ 9.41	-€ 2.27	-	-	-
% Difference	-10.92%	88.67%	-1.37%	-14.49%	95.26%	-2.51%			
	Base Prices October 2008			**Mid Prices October 2008**			**Peak Prices October 2008**		
	Sh. Price	Uplift	SMP	Sh. Price	Uplift	SMP	Sh. Price	Uplift	SMP
Actual	€ 73.81	€ 8.64	€ 82.45	€ 84.79	€ 10.56	€ 95.34	€ 105.89	€ 22.67	€ 128.56
PLEXOS	€ 65.65	€ 17.14	€ 82.79	€ 71.73	€ 24.34	€ 96.07	€ 85.09	€ 59.21	€ 144.30
Difference	-€ 8.16	€ 8.50	€ 0.34	-€ 13.06	€ 13.79	€ 0.73	-€ 20.81	€ 36.54	€ 15.73
% Difference	-9.09%	81.52%	0.41%	-12.94%	110.82%	0.76%	-14.74%	138.23%	12.24%
	Base Prices December 2008			**Mid Prices December 2008**			**Peak Prices December 2008**		
	Sh. Price	Uplift	SMP	Sh. Price	Uplift	SMP	Sh. Price	Uplift	SMP
Actual	€ 60.11	€ 3.49	€ 63.60	€ 65.92	€ 4.50	€ 70.42	€ 82.52	€ 9.91	€ 92.43
PLEXOS	€ 53.35	€ 9.45	€ 62.79	€ 56.68	€ 13.12	€ 69.80	€ 61.42	€ 36.63	€ 98.05
Difference	-€ 6.77	€ 5.96	-€ 0.81	-€ 9.24	€ 8.62	-€ 0.62	-€ 21.10	€ 26.72	€ 5.62
% Difference	-11.25%	170.77%	-1.27%	-14.02%	191.81%	-0.88%	-25.57%	269.65%	6.08%
	Base Prices March 2009			**Mid Prices March 2009**			**Peak Prices March 2009**		
	Sh. Price	Uplift	SMP	Sh. Price	Uplift	SMP	Sh. Price	Uplift	SMP
Actual	€ 33.27	€ 5.76	€ 39.02	€ 35.47	€ 7.26	€ 42.73	€ 40.61	€ 14.95	€ 55.56
PLEXOS	€ 33.01	€ 5.50	€ 38.51	€ 35.10	€ 6.80	€ 41.91	€ 39.14	€ 14.95	€ 52.20
Difference	-€ 0.26	-€ 0.25	-€ 0.51	-€ 0.37	-€ 0.46	-€ 0.83	-€ 1.48	€ -	-€ 3.36
% Difference	-0.78%	-4.43%	-1.32%	-1.04%	-6.32%	-1.94%	-3.64%	0.00%	-6.04%

4. Final Observations

A number of detailed points, observations and recommendations are made in the preceding parts of this Report. Here KEMA provides some final high level summary observations based on its experience of the conducting the PLEXOS validation exercise in 2009. These are:

Data

1. There are no major issues arising from updated generator and other model data;
2. Changes to generator data for 2009/10 are all supported by rationale; and
3. Other data changes (such as changes to demand and wind profiles) are also uncontentious.

Model

1. The same issues are seen to be arising in the PLEXOS model calibration as have been identified in the last two years;
2. In particular, differences in the unit commitment observed between PLEXOS and the actual market outcomes remains a key issue impacting on the accuracy of SMP forecasting;
3. This year, consistent with the previous year, the shadow price (under-estimation) and uplift (over-estimation) calibration discrepancies cancelled out each other; and
4. The goodness of fit across the year is considered to be very reasonable.

Process

1. The overall validation exercise was conducted in a very short timeframe this year; and
2. Given the modelling issues that continue to arise we would advise allowance for a greater timeframe next year to allow the potential need to conduct more detailed investigation and to identify, test & implement detailed model and modelling changes.

Appendix A. Weekly SMP Comparisons

Figure A-1: SMP Comparison: April 08 – Week 1

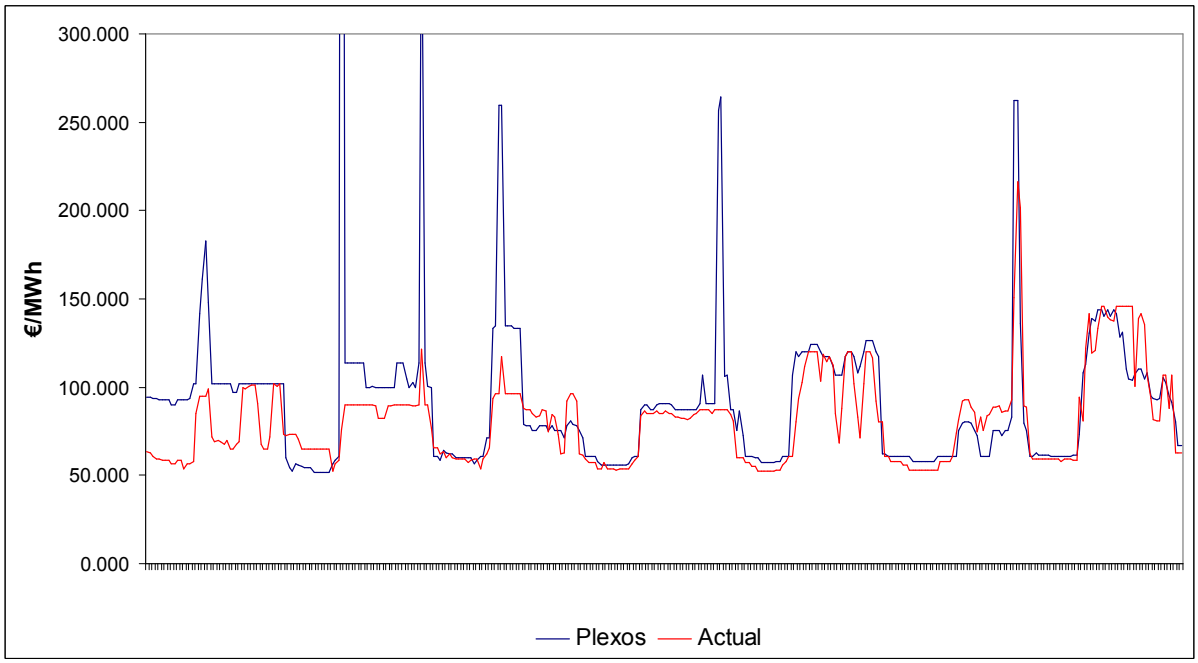


Figure A-2: SMP Comparison: April 08 – Week 2

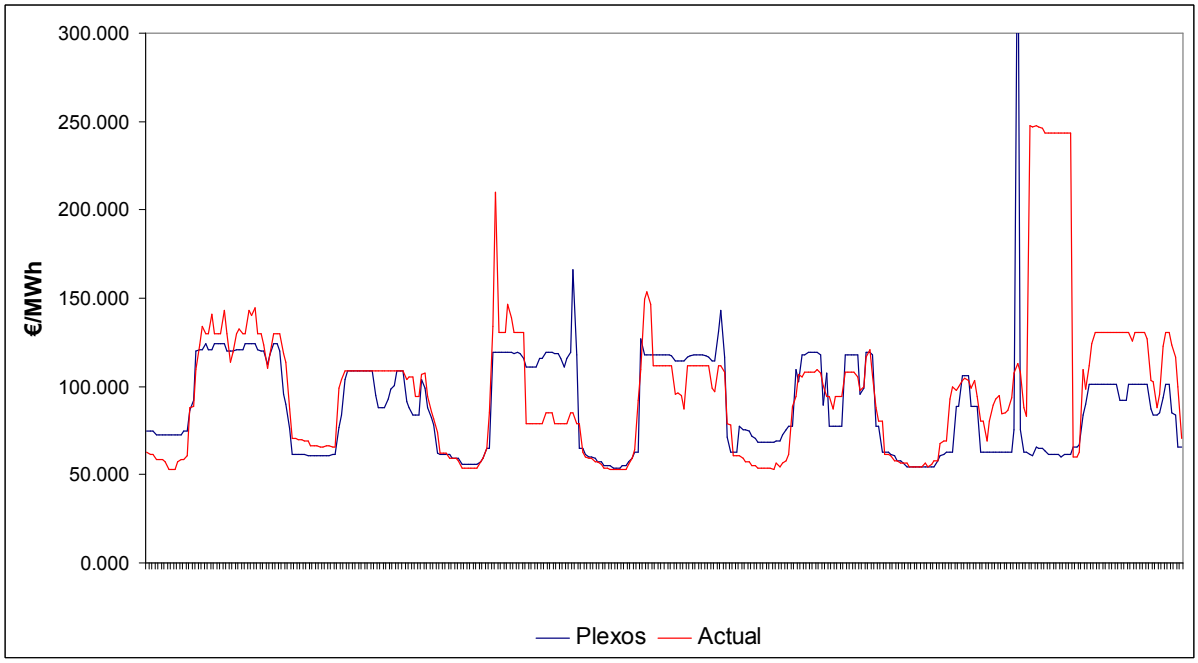


Figure A-3: SMP Comparison: April 08 - Week 3

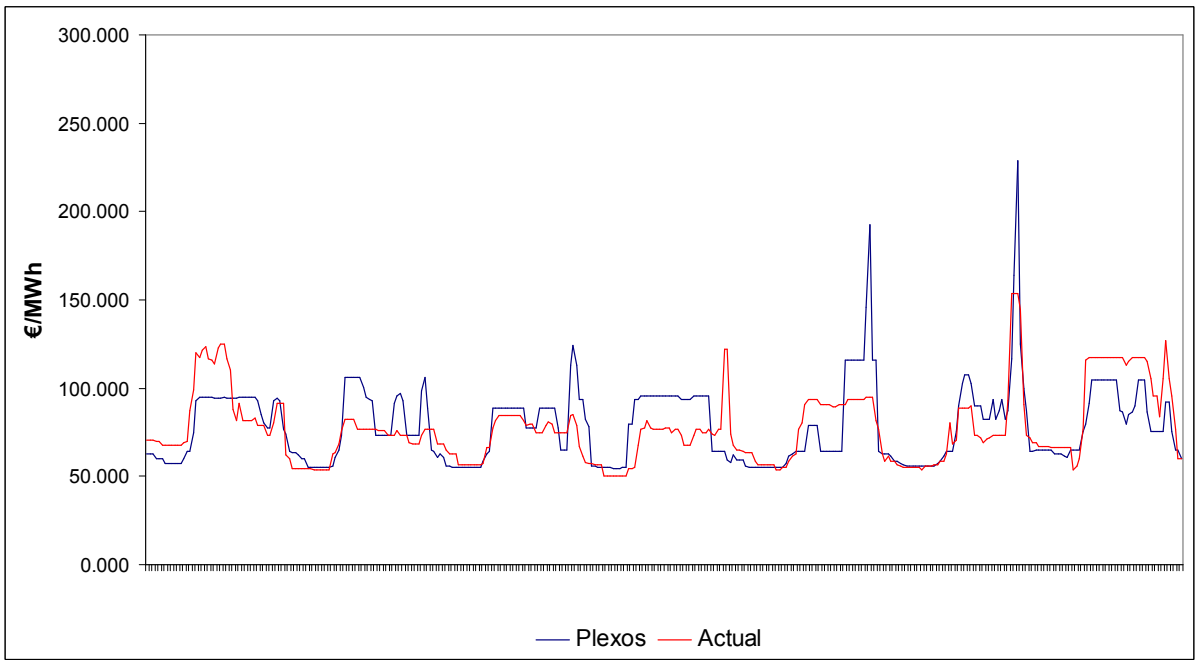


Figure A-4: SMP Comparison: April 08 – Week 4

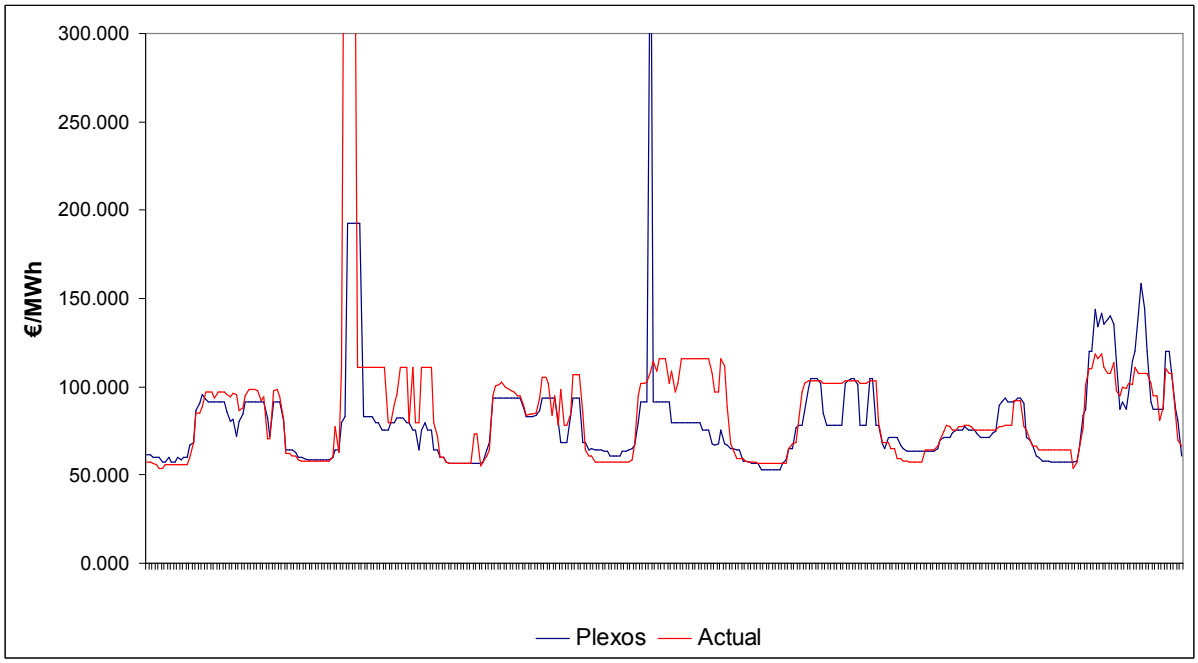


Figure A-5: SMP Comparison: August 08 – Week 1

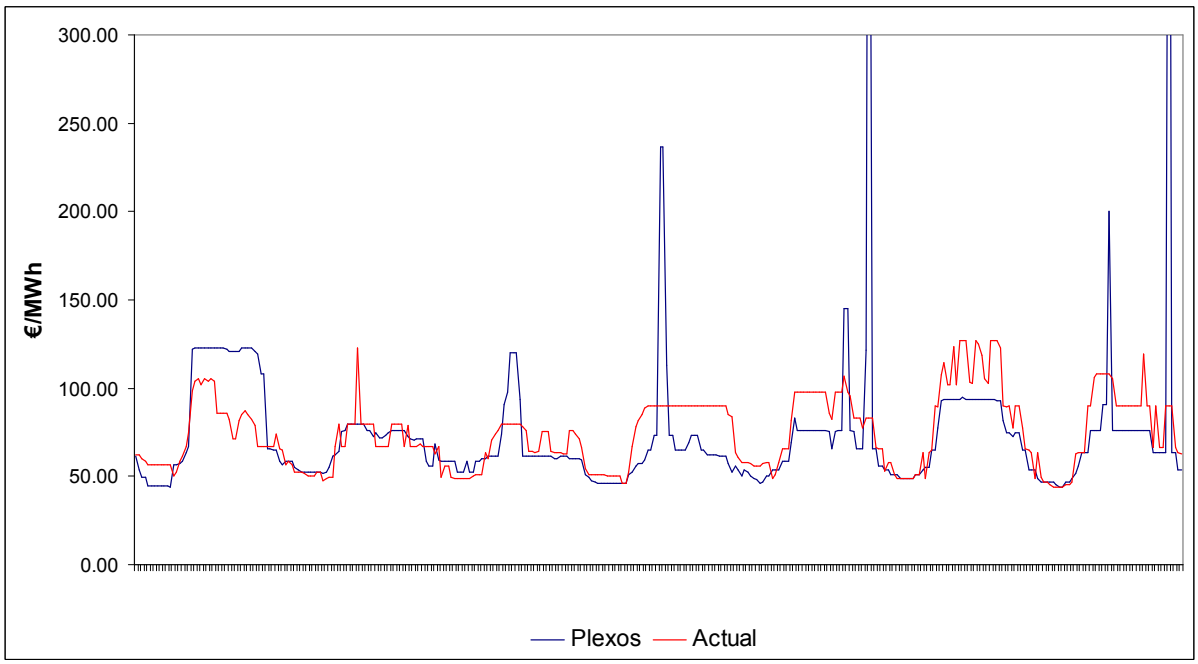


Figure A-6: SMP Comparison: August 08 – Week 2

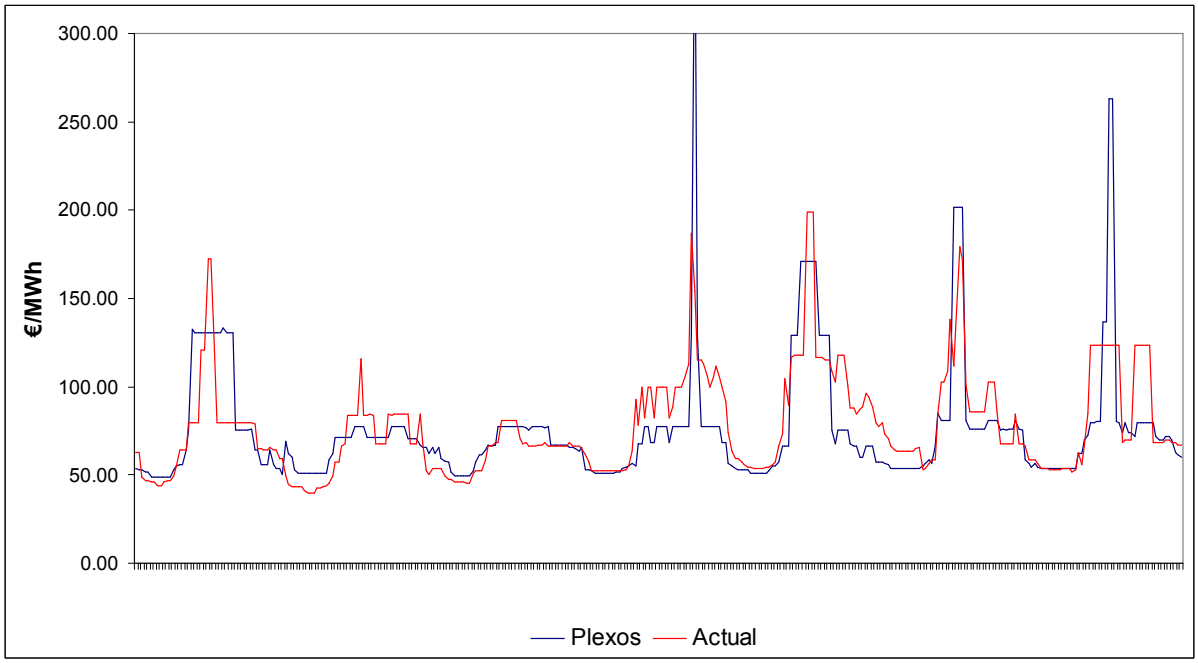


Figure A-7: SMP Comparison: August 08 – Week 3

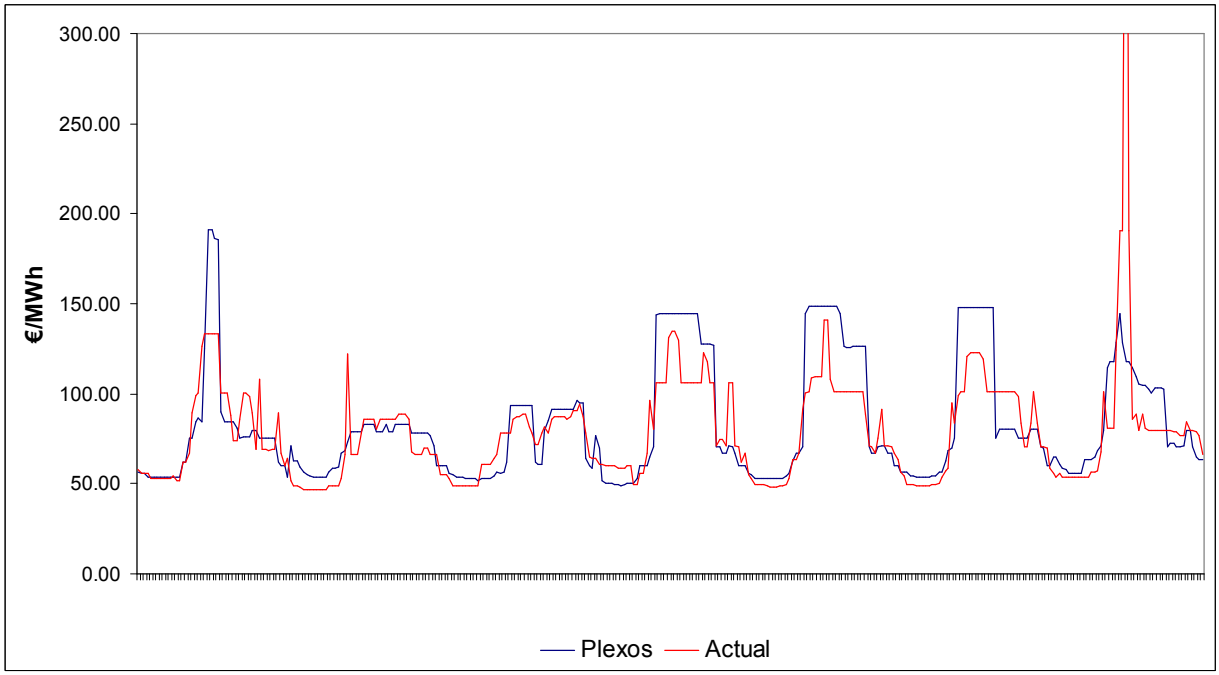


Figure A-8: SMP Comparison: August 08 – Week 4

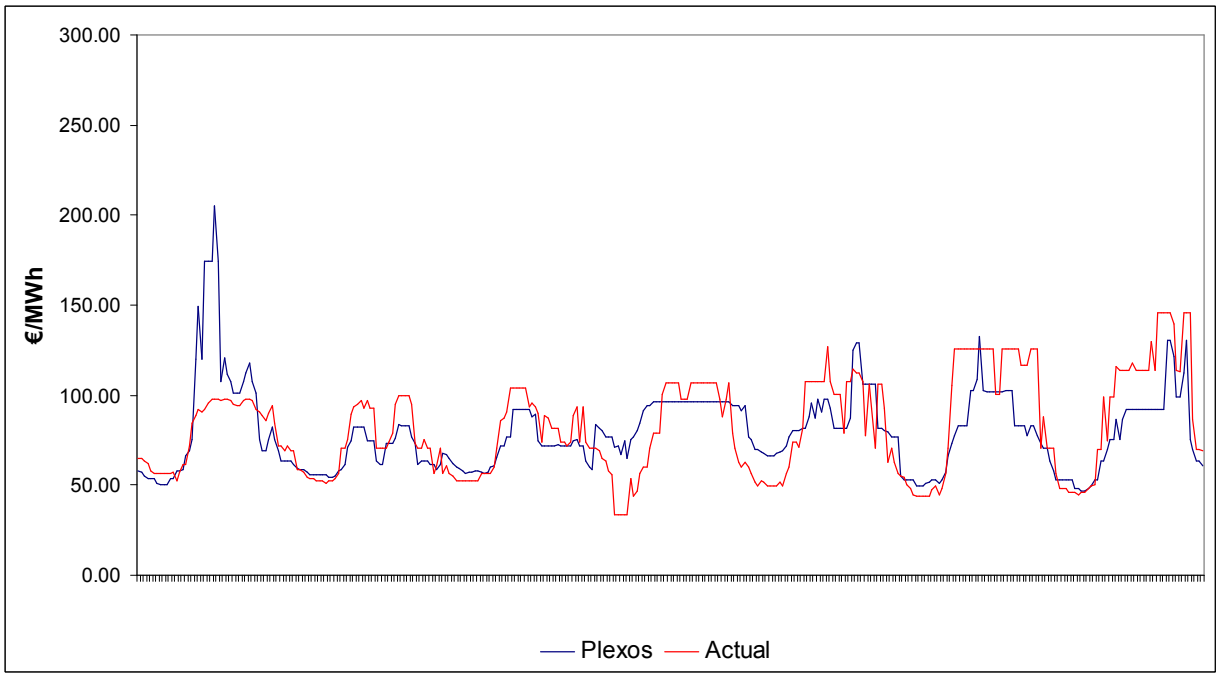


Figure A-9: SMP Comparison: October 08 – Week 1

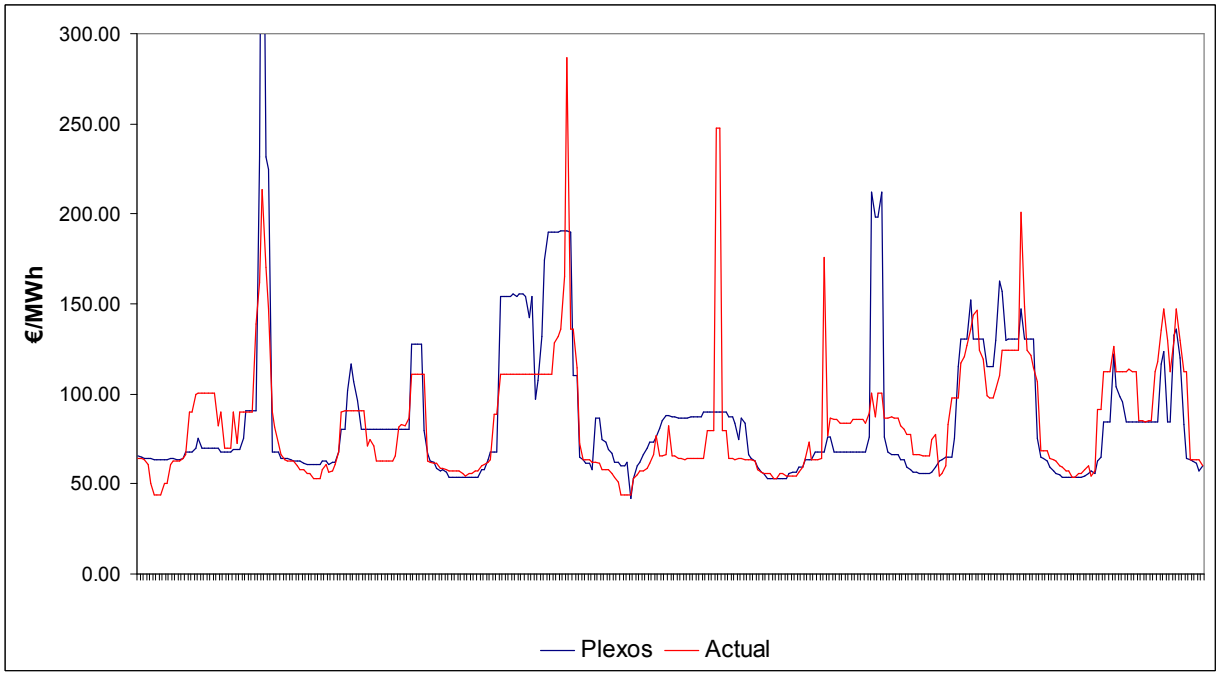


Figure A-10: SMP Comparison: October 08 – Week 2

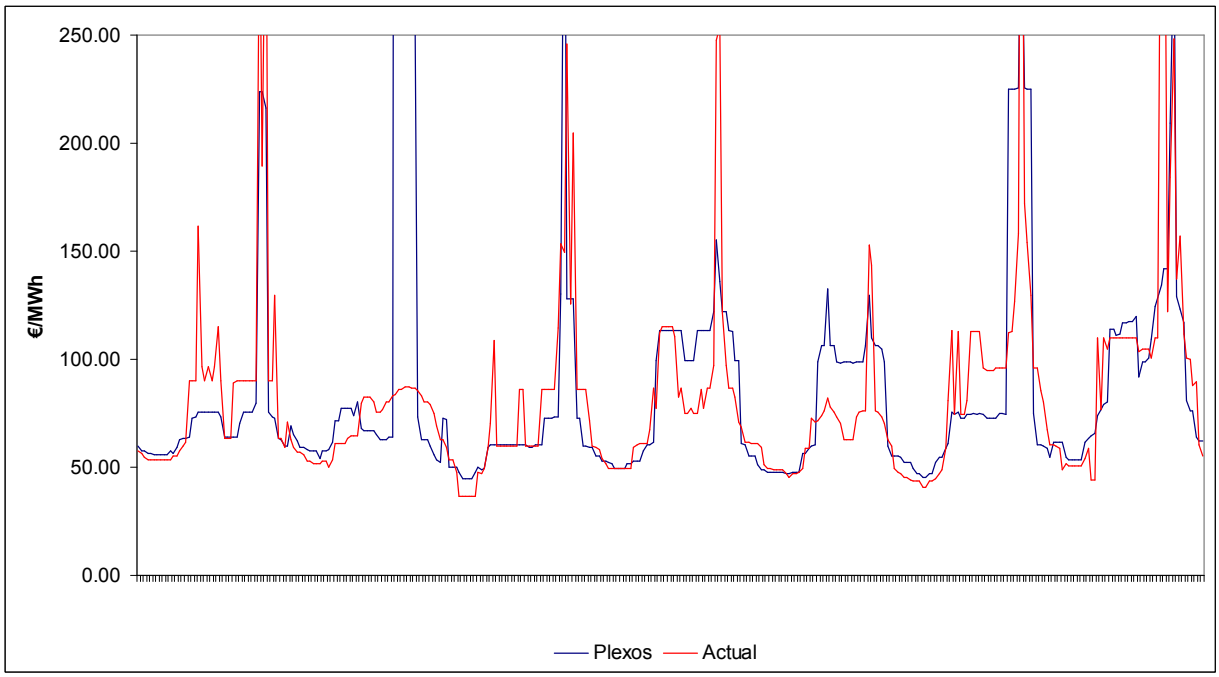


Figure A-11: SMP Comparison: October 08 – Week 3

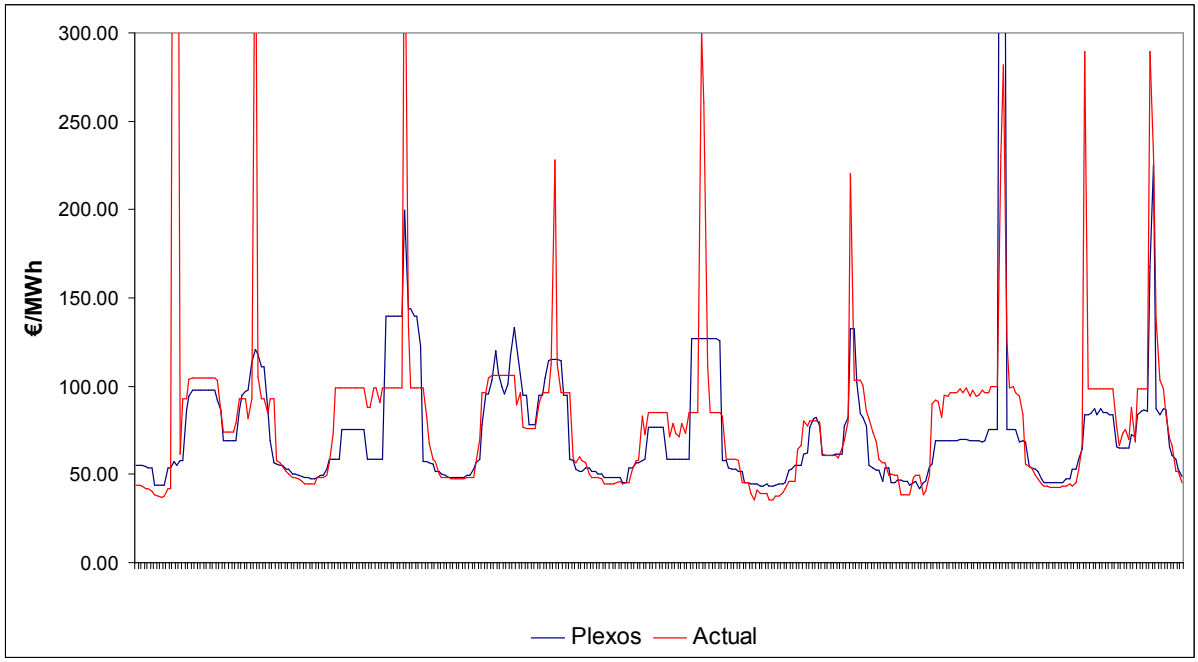


Figure A-12: SMP Comparison: October 08 – Week 4

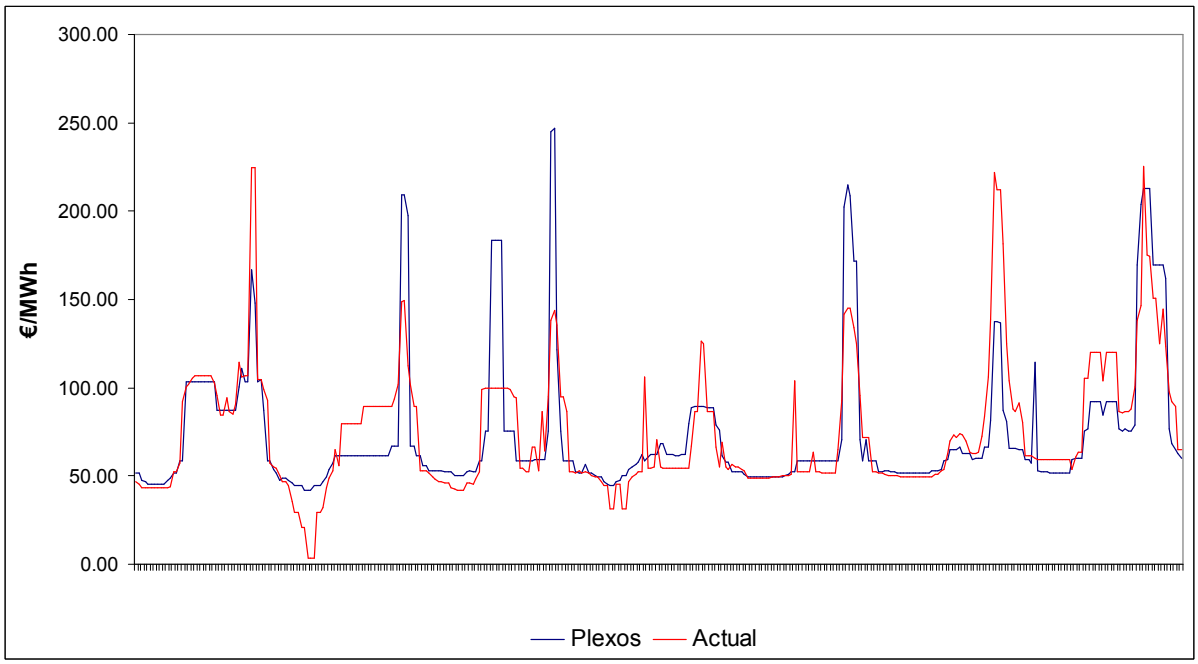


Figure A-13: SMP Comparison: December 08 – Week 1

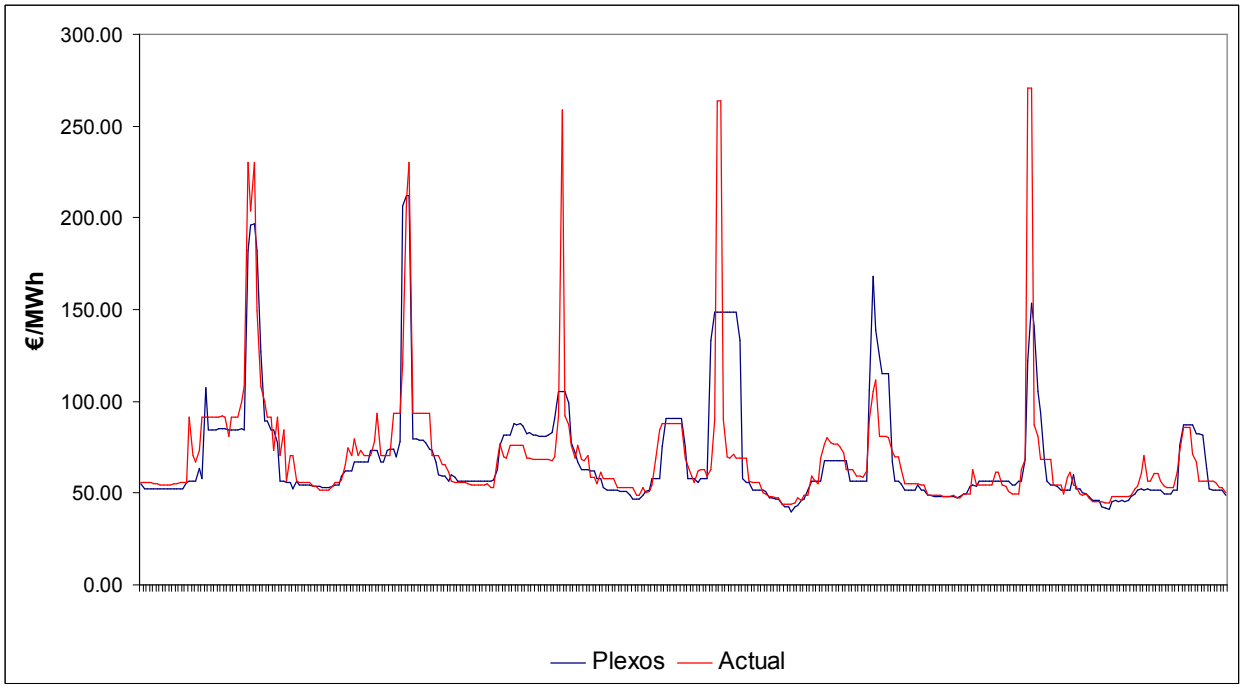


Figure A-14: SMP Comparison: December 08 – Week 2

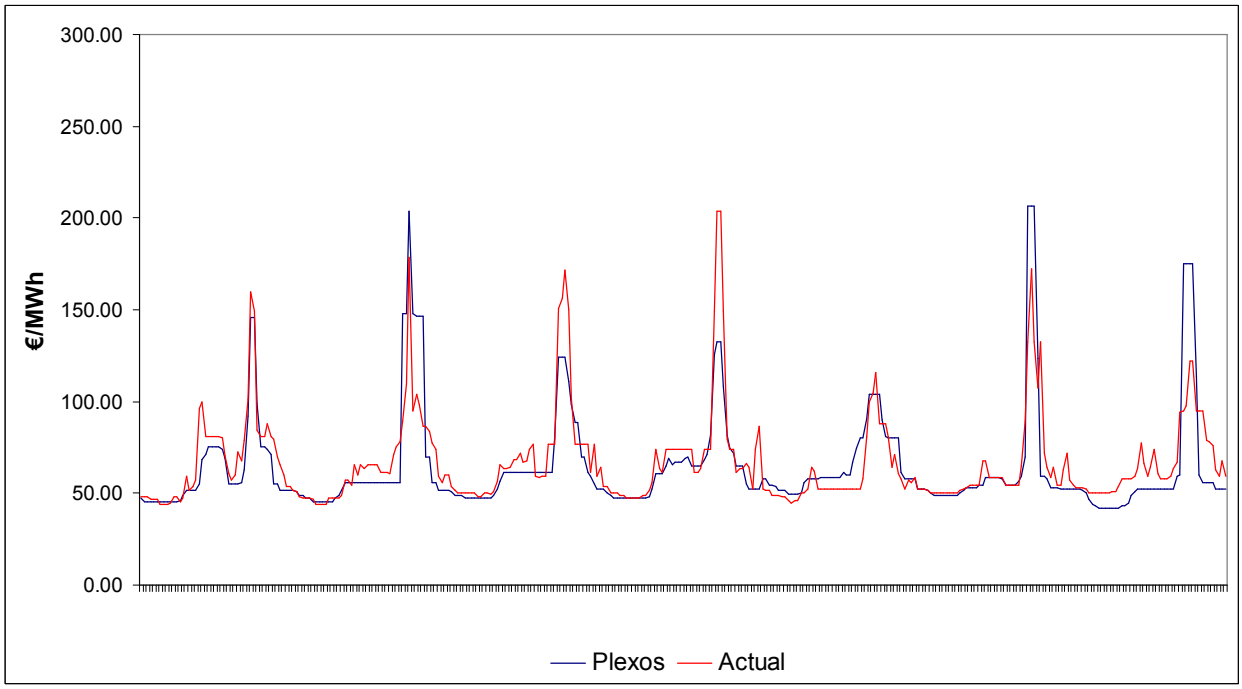


Figure A-15: SMP Comparison: December 08 – Week 3

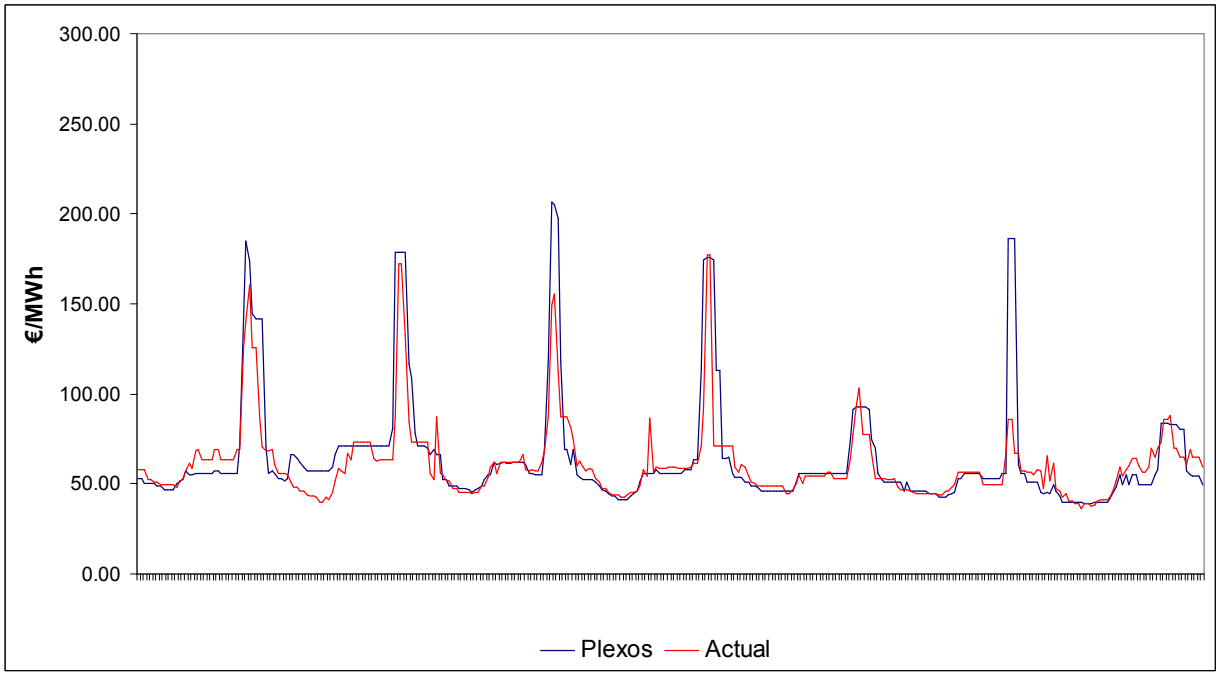


Figure A-16: SMP Comparison: December 08 – Week 4

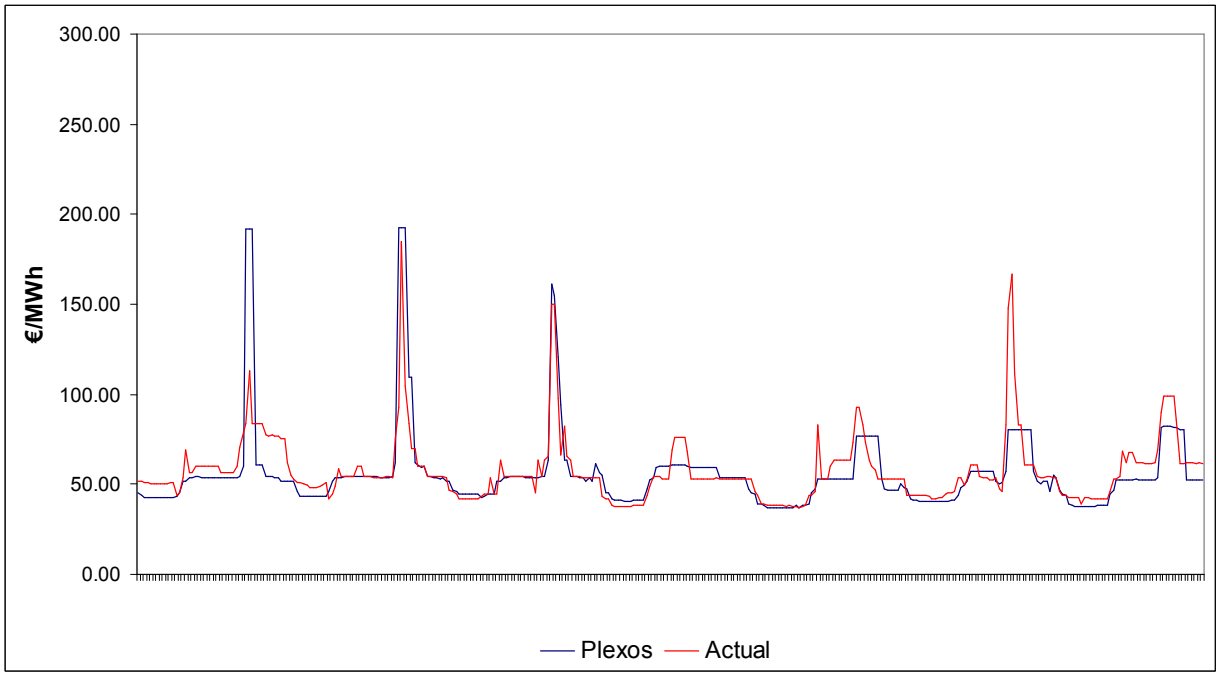


Figure A-17: SMP Comparison: March 09– Week 1

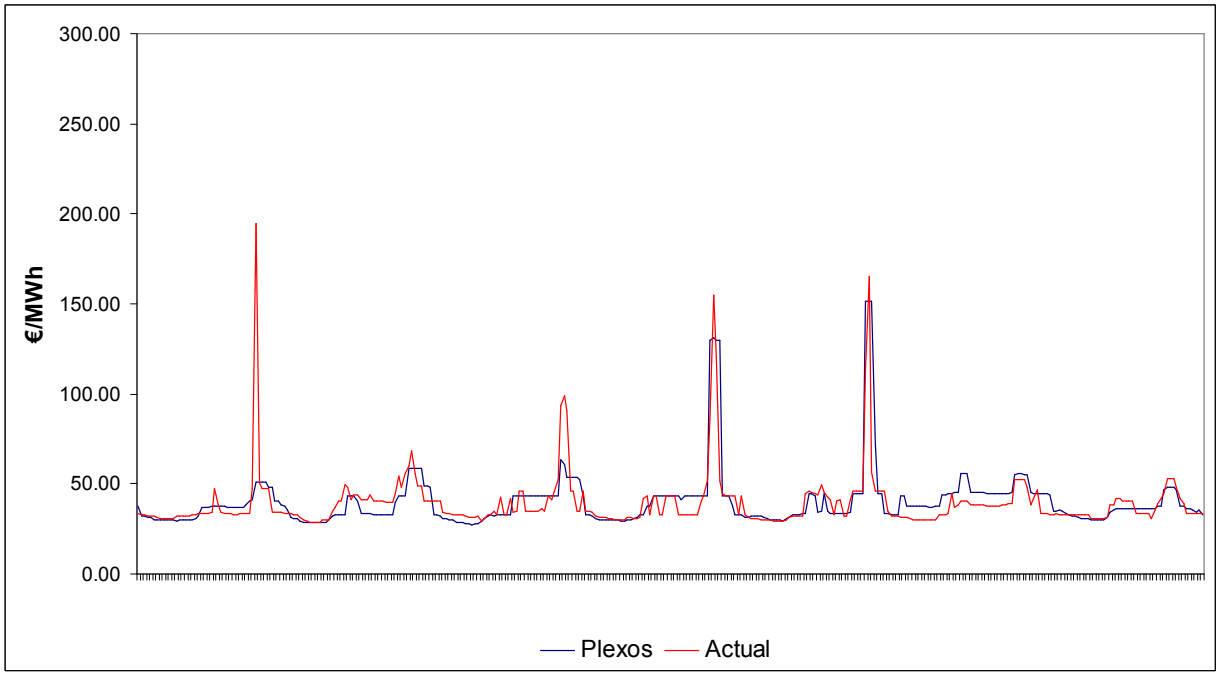


Figure A-18: SMP Comparison: March 09 – Week 2

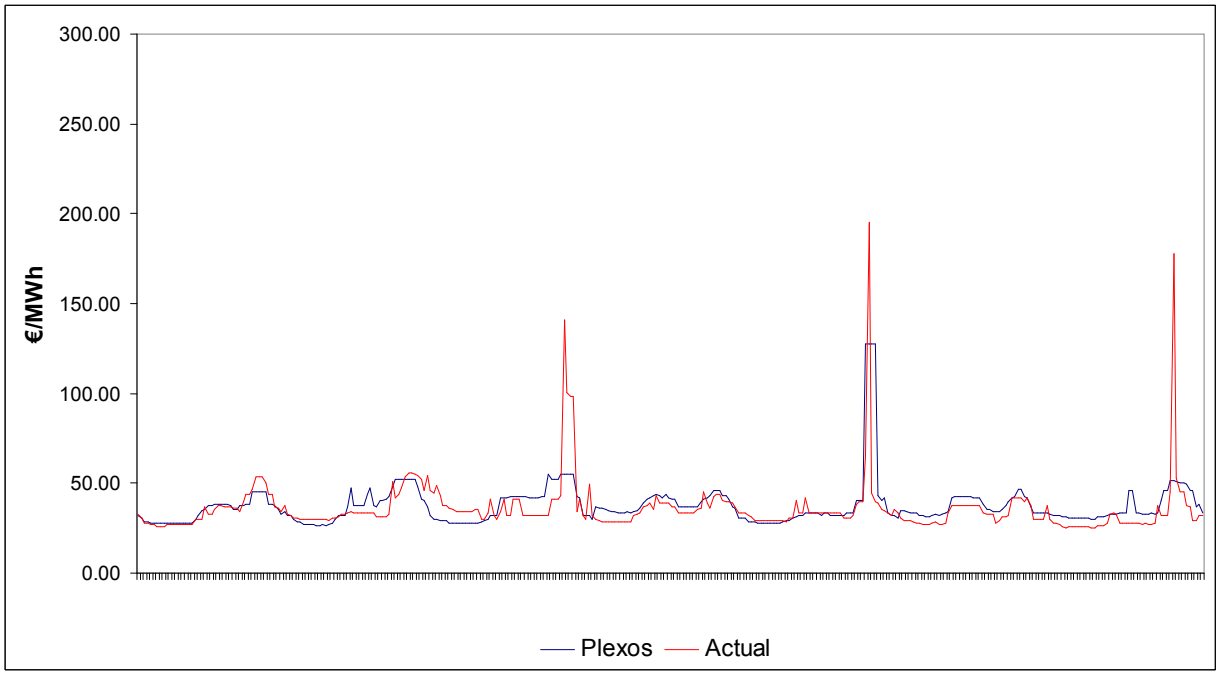


Figure A-17: SMP Comparison: March 09 – Week 3

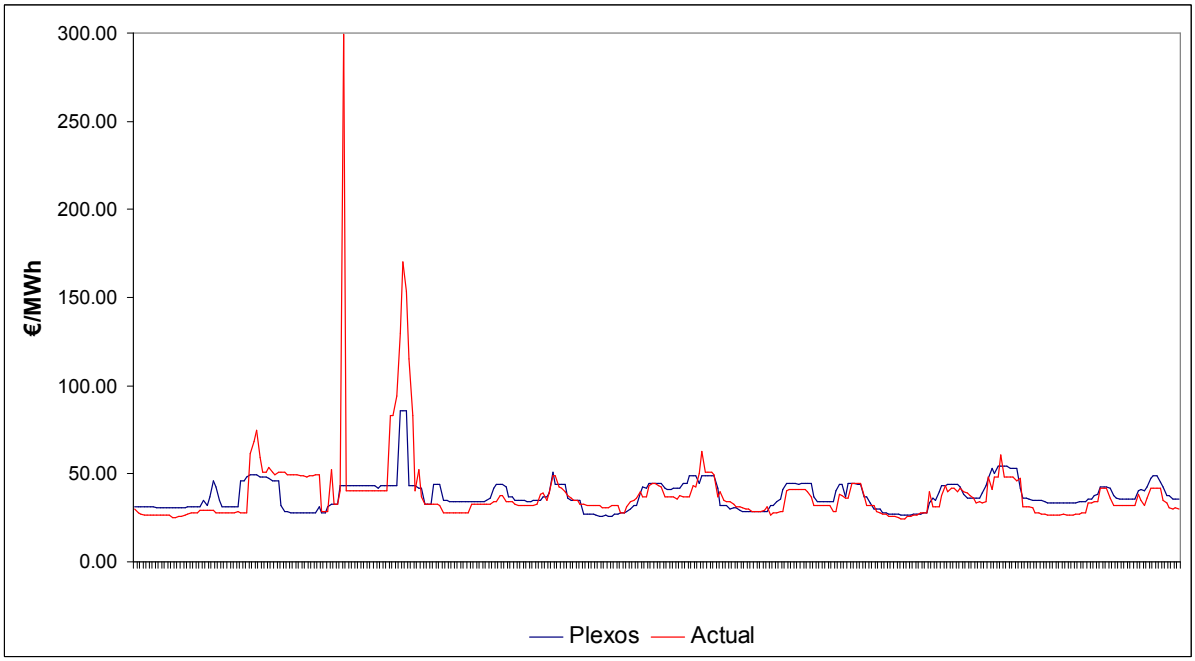


Figure A-20: SMP Comparison: March 09 – Week 4