Impact of Wind Generation on Electricity Prices in Day Ahead Market

Thi Kim Lien Nguyen

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UNIVERSIDAD PONTIFICIA COMILLAS

ESCUELA TÉCNICA SUPERIOR DE INGENIERÍA (ICAI)

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Author: **Thi Kim Lien Nguyen**

Supervisor: **Dr. Benjamin F. Hobbs**

Signed:…………………… **Date:………………………..**

Co-Supervisor: **Dr. Javier García González**

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SUMMARY

This master thesis aims at understanding the impact of wind on day-ahead-market (DAM) electricity prices using an integrated engineering-economic model. A realistic case study has been implemented, which is Electric Reliability Council of Texas (ERCOT) in Texas, U.S. in the month of August, 2014.

To address the main research question of wind´s influence on the level of DAM prices and its volatility, three main sub-questions to be answered are the followings: What is the connection between the theoretical marginal cost and the real electricity prices? How does changing wind load profiles influence electricity prices estimated in this study? And is there a better way of predicting the electricity prices to handle potential future changes more efficiently?

The methodology used for solving these research questions consists of two main parts. First, DAM electricity price forecasting weekday-models are designed through two stages: building a unit commitment (UC) model to find the theoretical marginal cost and constructing an econometric analysis to derive the relationship between this value and the real price. It should be noted that the UC model is built upon the most state-of-art formulation, which does not only overcome several drawbacks of the conventional energy-block UC scheduling but also includes a more realistic modeling of thermal generators, i.e., startups and shutdowns, different types of operating reserves. All models are tested under different time frames, which are created by swapping the order of different weeks in the studied month. Amongst all, the most robust one is selected. After completing task one, the first and third research sub-question could be answered. In the second task of the methodology, different wind loads are fed into the best obtained model from the first task and their impacts on predicted prices are examined to respond to the second research sub-question. Finally, upon completion of the thesis, the main research question will be fully answered.

The main conclusions of this master thesis are the followings. First, the hybrid model combining an engineering UC approach and an econometric regression model has been proved to outperform both pure engineering and time series models. Importantly, this hybrid model could be used to predict the future electricity price one day in advance with high accuracy, thus, it could provide a significant contribution to the current electricity price forecasting tools. Second, wind generation generally has a negative impact on both electricity prices level and its deviation, i.e., increased wind generation drops the level and deviation of electricity prices and vice versa. The increased or decreased cost is coming from the changes in operating cost of thermal units, e.g., startups and shutdowns and fuel costs, and thus depends on the generation mix of the system. For instance, the average price deduction in the system with threefold increase of wind generation varies from around 3% to nearly 9% in the system with a fourfold increase of wind output. And the changes in price deviation are explained by an increase or decrease in price gaps between the off-peak and peak periods.

The thesis starts with a brief introduction and literature review about impact of wind on electricity prices and price predicting techniques. The mathematical formulation and input data are presented afterwards. Finally, numerical results along with discussions and comparisons are shown at the last chapter of the thesis, followed with the appendix with detailed calculation and model´s numerical outputs as evidential support.

ACKNOWLEDGEMENT

During this whole educational and rewarding experience, I have been extremely blessed to receive so much help and support of many, without whom it would not have been possible.

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1. INTRODUCTION

This chapter introduces the background and motivation behind the writing of this thesis and defines the objectives.

1.1. Background

Renewable energy is getting higher importance nowadays because of the growing concern about climate change and its positive externalities, e.g., reducing dependency on fossil fuel and keeping fossil fuel prices at reasonable levels. Amongst all, wind power has become a mainstream source of electricity generation worldwide; it is the fastest growing renewable source of electricity generation in the U.S., rising from a mere 5% of total renewable generation in 2006 to one-third of the total in 2013[1]. At the same time, the U.S. has more wind energy powering its grid than any other country in the world, contributing 27.7 % of the world's wind generation in 2011[2]. It is also evident with a rapid increase in U.S annual net wind generation of 27 times from 6,737 GWh in 2001 to above 181,791 GWh by 2014 as shown by Figure 1.1. Thus, wind generation is critical to the U.S. energy market.

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[1] http://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_1_01_a

[2] http://www.bp.com/liveassets/bp_internet/globalbp/globalbp_uk_english/reports_and_publications/statistical_energy_review_2011/STAGING/local_assets/pdf/renewables_section_2012.pdf

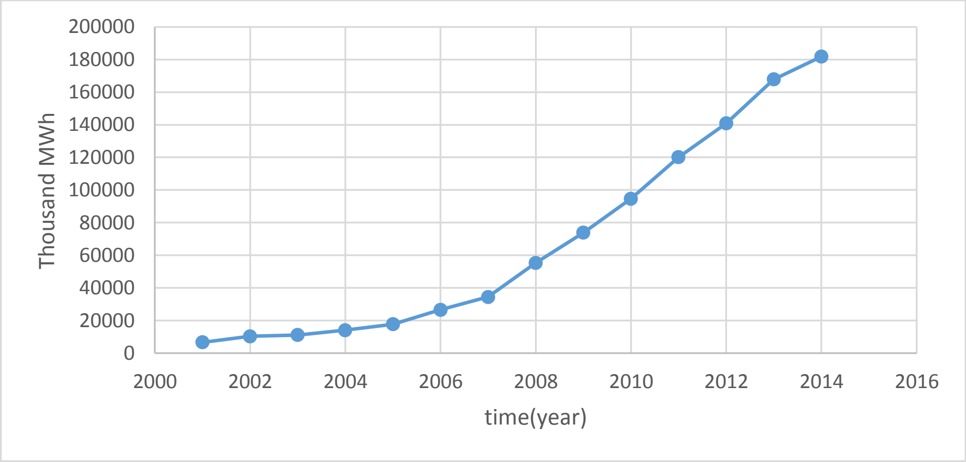

Figure 1.1: Net wind generation for wind, annual in U.S. Source: U.S. EIA.

However, wind generation development is confronted with a number of challenges as it happens with other renewable energy sources. The intermittency (random unavailability) and the volatility (fluctuations during the available hours) of wind generation influence the power system characteristics such as bus voltages, frequency, system balancing, and generation adequacy [1]. The power imbalance is especially a noticeable challenge. When wind generation exceeds power demand, the excess has to be curtailed. However, during unforeseen shortage of wind generation, back-up conventional generation has to be dispatched, pushing the system cost higher. This might offset some of the expected benefits of wind generation.

In several major electricity markets in the U.S. (e.g., California ISO (CAISO), PJM Interconnection (PJM), Electric Reliability Council of Texas (ERCOT)), the Security Constrained Unit Commitment (SCUC) model is used to select the generation offers that result in the lowest system cost by means of solving an optimization problems [53]. Given the low (almost null) marginal cost of wind farms, wind generation is dispatched first displacing conventional generators in the merit order curve. The subsequent chosen generations then need to adjust their output accordingly. Since around 80% of power generated in the U.S. still comes from thermal power plants[3], the presence of wind jointly with the limited energy storage capability has therefore imposed a need for greater flexibility on these thermal units

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[3] http://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_1_01_a

and the whole electricity market in general. Thus, a smooth integration of variable renewable electricity imposes a challenging task.

1.2. Motivation

The interaction between renewable energy sources, e.g., wind, solar generation, and conventional thermal units have a direct effect on the resulting hourly scheduling, and inevitably affect electricity prices. However, assessing the impact of introducing wind generation on market prices is not a simple task. Indeed, since wind generation started to be deployed in many power systems, its implications to prices of electricity [54], ancillary services [55], and capacity [56] have been the subject of intense research during the resent years.

One of the main issues is the price behavior and dynamics of the day-ahead wholesale electricity prices. On the one hand, existing literature suggests that within the context of competitive generation markets, the increase in wind generation has generally led to a reduction in DAM prices. On the other hand, this fall in prices is accompanied by the increase in price variation[4] [2][3].

Due to the concern over the increase of variation in prices, the forecasting of electricity prices is therefore important for both the participants in the generation market as well as the regulators. To be specific, for the generation companies as the market participants, the forecast of DAM electricity prices is important to help them adjust their daily bids. Moreover, forecast for a longer time period (e.g., for the next 12 months) could also help companies to adjust the monthly schedules of contracts in order to maximize their benefit [4].

In the forecasting of electricity prices, two approaches can generally be identified: fundamental models and statistical models [5]. Fundamental models are inspired by the traditional cost-based models (common in the power system's generation,

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[4] Price variation here is measured by the standard deviation or variance of prices over the period of study, as opposed to price volatility which only refers to the variation of price from period to period. Price volatility is also hypothesized, but as [3] suggest, the evidence is limited. In this thesis, we will focus on price variation.

operation, and control) where a detailed representation of the generation units and system constraints are modeled to find the optimal dispatch of the generators, flows through the lines, etc. The dual variable of the demand balance equation in a minimum cost dispatch model represents the marginal cost of the system (or the nodal marginal cost in case such equation is formulated at each node of the network).

In a general Unit Commitment scheduling approach, non-convexities exists, for example startup and shutdown costs as well as output constraints, e.g., minimum output requirement. Moreover, it is widely accepted that with the presence of non-convexities, there will be no linear prices that could support an equilibrium [57]. However, in [58] it is mentioned that the prices derived from solving a Mixed Integer Program (MIP) and an associated linear program have a corresponding analogy to non-linear prices. Thus, the dual variables could also be used as prices to clear the market in the presence of non-convexities. Furthermore, as one of the main drivers of electricity prices is the marginal cost. Obtaining a good estimation of the marginal cost could be very useful for modeling the electricity prices. In fact, in a perfect competitive market, the electricity prices should be equal to the marginal costs.

Statistical models rely on time series or econometric techniques by using the available historical data of prices and causal variables. Both approaches have their own drawbacks [6]. The fundamental models require extensive fine-tuning of the input to take into account factors such as strategic behavior to obtain results that align with the observed prices. Meanwhile, statistical models, by relying only on historical prices, are not sufficiently rich to handle possible future changes due to, for instance, regulatory changes.

Due to these drawbacks, the quality of prediction results using these two approaches might be compromised. A new approach combining the fundamental and statistical approached, called ‘hybrid approach’ is therefore proposed in [6]. Furthermore, in forecasting DAM electricity prices, econometric techniques typically require price data from several periods prior to the study period. For instance, in [4] the data of real electricity prices of the previous five hours is required to predict the next hour in DAM Spanish Electricity Market. If prediction could take place 24 hours in advance, it could give players more flexibility in dealing with unexpected future changes.

1.3. Research questions

The wholesale electricity markets are complex in nature. This research aims to specifically look at the relation between wind generation and DAM wholesale electricity price. A general research question is formulated as:

> "What might be the impacts of wind generation upon the level of day-ahead electricity price and its volatility in a regional market in the U.S?"

To answer the research question, this thesis aims to make a case study using publicly available data from the Electric Reliability Council of Texas (ERCOT) system during the summer month of 2014 as will be explained in Chapter 3. Moreover, the following sub-questions will also be addressed in the research:

(1) What is the relationship between the theoretical hourly marginal costs and the observed hourly electricity prices?

(2) How does changing wind load profiles influence electricity prices estimated in this study?

(3) Is there a better way to predict the DAM electricity prices under the large presence of intermittent wind energy?

Experimental research designs include the following:

1. Design DAM forecasting models using both fundamental and hybrid approaches, which consists of two stages:
    a. First stage: Build a Unit Commitment (UC) model based on a state-of the art work to find the theoretical marginal cost.
    b. Second stage: Build an econometric regression analysis to find the relationship between estimated marginal cost and the real prices.

2. Simulate the best model from (1) with different wind profiles to examine its effects.

The first part of the experimental research is designed to answer the first sub-question while the second part to answer the second sub-question. Finally, the findings from the two experiments will be synthesized to answer the third sub-question as well as main research question.

1.4. Thesis outline

The outline of this thesis is as follows. The second chapter sets up the framework of this study with the literature review. In this chapter, the focus is put on the three main topics, namely: impact of wind on electricity prices in DAM and predicting electricity prices in DAM and some remarks on the UC model,. Finally, the literature review closes with a summary of the finding and expected contribution of this work.

The third chapter introduces the methodology used in this work, which consists of using a state-of-the-art UC model to derive an estimation of the electricity prices and an econometric regression analysis to find out the relationship between the estimated and real prices.

Chapter 4 describes the ERCOT system in Texas, U.S. to explain why it is very relevant system to conduct the study. Data gathering and derivation of generator parameters are demonstrated in detailed in the second part of the chapter.

Next, the first task of building DAM forecasting models is carried out in Chapter 5 and first half of Chapter 6. Chapter 5 presents two main results from the first stage with UC models, consisting of UC dispatch and theoretical marginal cost. The chapter closes with an output validation. Subsequently, the second phase is conducted in Section 6.1 with econometrics regression models, in which real prices are dependent variable and estimated prices are among independent variables. Three main categories of models are studied, namely: a purely time series model, two pure UC regression models and four hybrid regression models, further details are explained at the beginning of chapter 6. Model comparison based on different criteria is following in Section 6.2 and the best model out of a total of seven is chosen. The second task is presented in Section 6.3, in which the best model obtained from Section 6.2 is simulated with different wind load profiles.

Finally, the findings from chapter 5 and chapter 6 and answers to the research questions proposed in chapter 1 are recapitulated in chapter 7. This conclusion part ends with recommendations for further research.

2. LITERATURE REVIEW

This chapter provides the theoretical background for this master thesis. The first section covers the existing literature on the impact of wind generation to electricity prices. The second section reviews the forecasting methods commonly used to predict DAM electricity price.

2.1. Impact of wind on wholesale electricity prices

As mentioned in the introductory chapter, empirical evidence on the impact of wind generation to electricity prices suggests in general the reduction of prices accompanied with increased price variation. This section provides a more detailed insights into these aspects hypothesized in [2] and [3] .

The assessment of wind impact to the level of electricity prices is focused on the examination of the merit-order effect. As explained in [8], merit-order effect arises due to market clearing mechanism that selects generation offers based on their merit-order. Figure 2.1 shows this merit-order effect in a stylized form. The demand curve is assumed to be inelastic for a day-ahead market in the short-term while the supply curve is simplified as a linear curve. Electricity generated by renewable sources is bought first due to merit order. Therefore, it has the similar effect as the reduction of demand, shifting the demand curve from D_1 to D_2. As the result, day-ahead price will be theoretically reduced from P_1 to P_2.

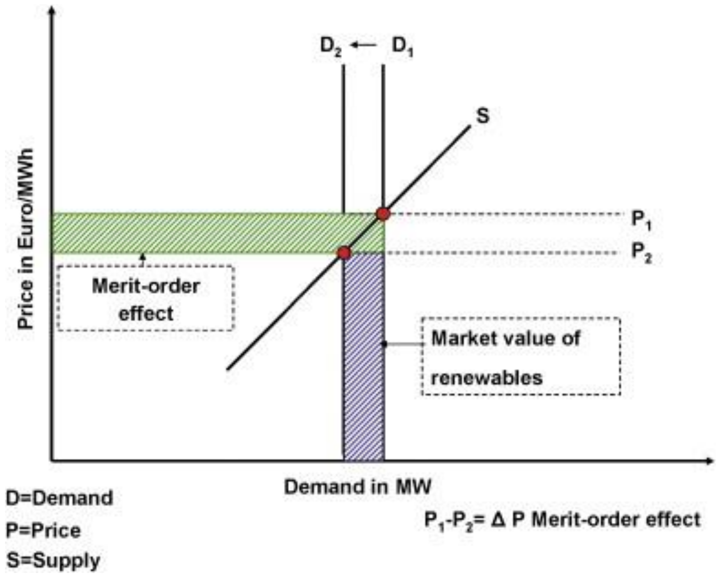


Figure 2.1: Merit-order effect of renewable electricity generation. Source: [8]

This merit-order effect has been studied in [2][8][10][12]. In Texas between January 2007 to May 2010, [2] observes average price reduction per 100 MWh increase in wind generation of \$1.3/ MWh in the South zone, \$1.4/ MWH in Houston zone, \$1.6/ MWH in the North zone, and \$4.4/ MWH in the West zone. This is equivalent to 2 – 9% reduction in wholesale electricity prices.

In addition, increase in wind generation also tends to increase price variation [2][3][11]. Particularly in Texas, [2] observes that 10% increase in the installed capacity of wind generation leads to about 1% increase of price variance, in the non-west zone and about 5% increase of price variance in the West zone. Since the West zone of ERCOT also experienced the highest price reduction, it appears that higher price reduction due to higher wind generation would be accompanied by higher increase in price variance.

2.2. Predicting electricity prices in day-ahead market: fundamental, statistical, and hybrid approaches

In [6], the author argues that forecasting of electricity prices has become an important priority due to the deregulation of power systems. This concern becomes even more pertinent in the presence of renewable generation. As the previous section has shown, wind generation could lead to the increase in price variation. [11] suggest that as a consequence of the increased in price variation, generators will face significant variation in profits year-to-year. This further strengthens the case for a robust forecasting approach.

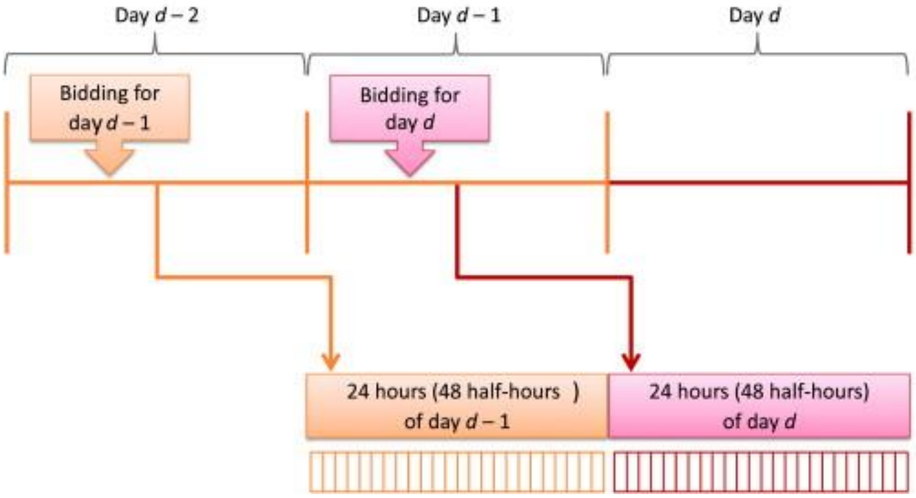


Figure 2.2: Illustration of the day-ahead market. Source: [8]

First, it is important to be clear on what prices are being forecasted. In this thesis, the focus is on prices in the day-ahead market, where generators submit their bids for the delivery of each hour or each period of the next day. Figure 2.2 illustrated the timeline of this process. This is different from the intraday or real-time/ balancing markets.

In general, there are two main approaches to forecast electricity prices: fundamental models and statistical models [6]. Fundamental models build on the conventional cost-based engineering approach which takes into account characteristics of generators and system constraints to find the optimal dispatch of generators, traditionally from a structural point of view. In a market environment, fundamental models can be classified into three major groups depicted in Figure 2.3, i.e., optimization, equilibrium and simulation models [13]. Optimization models can help market participants to find the solution that maximizes their expected profits (difference between market incomes and costs). In this case, modeling the effect that their actions can have on resulting market prices can be challenging (price-maker case). Optimization models can also be used by the System or Market Operator to clear the market when the scheduling is obtained by means of a UC model, with the possibility of taking into account the network in order to obtain nodal prices.

Equilibrium models intend to capture the strategic interdependence among market participants. The simultaneous consideration of the optimality conditions for all the involved participants results in a set of equations that can be solved by mathematical programming techniques such as Mixed Complementary Problem (MCP). Simulation models have a similar goal, but in this case, other techniques (heuristics) such as evolutionary agent-based models, are used to find the solution. Even though these two types are considered as alternatives, Figure 2.3, the simulation models are often used when the problem is too complex to be addressed within a formal equilibrium framework. A very popular approach to model the market equilibrium is the Cournot model, in which firms compete in quantity strategies. Its main drawback is that it requires a proper inverse demand function in order to establish the resulting price as a function of the total quantity produced while in many electricity markets, demand still has inelastic behavior. Another approach is the Supply Function Equilibria (SFE), where firms compete in offer curve strategies. This strategy is more realistic as the decisions made by market participants are the bids submitted to the power exchange. However, solving the SFE requires to introduce strong hypothesis in the cost functions. Although these two approaches are different in terms of strategic variable (quantities vs. offer curve), they share the same concept of Nash equilibrium, where the model equilibrium is obtained when each firm’s strategy is the best response to the strategies of its competitors. There are intermediate approaches, such as Conjectural Variations where different price sensitivities can be introduced for each agent.

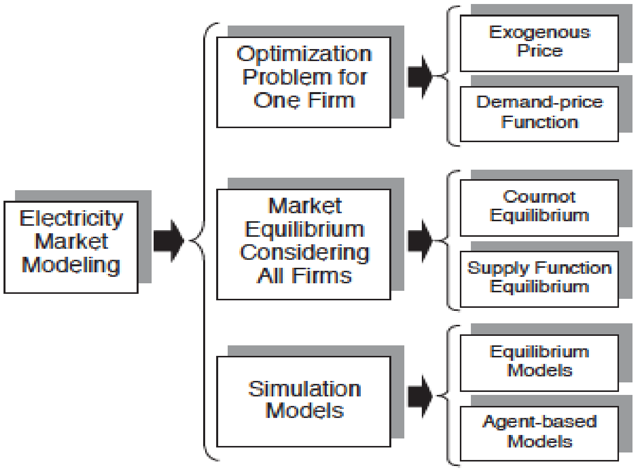


Figure 2.3: Schematic representation of the electricity market modeling trend. Source: [13]

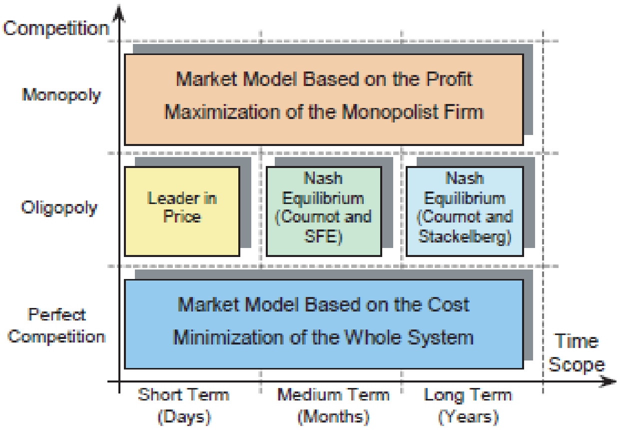


Figure 2.4: Theoretical electricity market models depending on competition and time scope. Source: [13]

Another way of categorizing different electricity market models is according to the level of competition and time scope as shown in Figure 2.4. In the short-term scheduling where each generator´s maximum capacity is fixed and SU & SD are of significant importance, [14] presented a model to help the generating companies to make optimal short-term decisions in the case of being a price-maker. In this model, the firm tried to maximize its profit by taking its residual demand function, which links the price to its own output [4][6][13].

Most of these fundamental models require an adequate estimation of the residual demand curves (i.e., the aggregated information of the bids submitted by all the competitors). Hence, model's results often require a fine turning of the input data to obtain results that are aligned with the observed prices.

An alternative approach to forecast electricity prices is to apply statistical techniques, econometric models by using the available historical data of prices and explanatory variables. DAM electricity prices models based on time series are used extensively in the literature, both with stationary models (Dynamic regression models [15], ARIMA models [16]) and non-stationary models (Mean-Reversion Models [17], and GARCH models [18]).

However, statistical models, by relying only on historical prices and other explanatory variables that have causal relationships with price, are not sufficiently rich to handle possible future changes due to, for instance, regulatory changes. Furthermore, in forecasting, econometric techniques typically require prices of previous few hours, for instance, in [4] to predict the next hour in DAM Spanish Electricity Market, data of real prices of the previous five hours are necessary. If prediction could take place 24 hours in advance, it could give players more flexibility in dealing with these future uncertainty.

The dual variable of the demand balance equation in a minimum cost generation dispatch model is equal to the marginal cost by definition. In a perfectly competitive market, the theoretical marginal price should be equal to the system marginal cost. Therefore, estimating the marginal cost by means of a fundamental model could be very valuable to model the price. Added information regarding the electricity market behavior could be derived from the obtained results, e.g., Lerner index, which is an index of market power measured by the difference between price and marginal cost expressed as a percentage of price. Consequently, a new approach combining the fundamental and statistical approaches, called ‘hybrid approach’ is proposed in [6] and will be used in this study.

3. UNIT COMMITMENT MODEL AND ECONOMETRIC MODEL

The objective of this chapter is to provide a detailed description of the theoretical framework used in this master thesis. The first section covers some remarks on UC model and on its mathematical formulation to derive an estimation of marginal cost. The second section presents the econometric model to find the relationship between the estimated marginal costs and real prices.

3.1. Unit commitment model

The unit commitment problem is the task of scheduling generator start-ups and shutdowns over a period of time to minimize the cost of serving expected demand while operating the power systems within secure technical limits. UC-based Market Clearing (MC), in which energy and operating reserves are simultaneously cleared, is widely accepted as the most economically efficient method to run DAM [19]. It is due to the fact that simultaneous clearing could avoid uneconomical out of merit-of-order operation and mitigates potential market power when hierarchical substitution of reserves is considered [19].

In UC-based MC, it is assumed that the generators participating in the market are brought into operation through economic merit order of loading. Under this assumption, the market-clearing price at a specific hour is equal to the operating cost of the last unit used to meet the load prevailing at this hour, which is called the marginal unit [20]. Hence, by building a UC-based MC model, the obtained theoretical clearing price could be used as a reliable reference for the real prices.

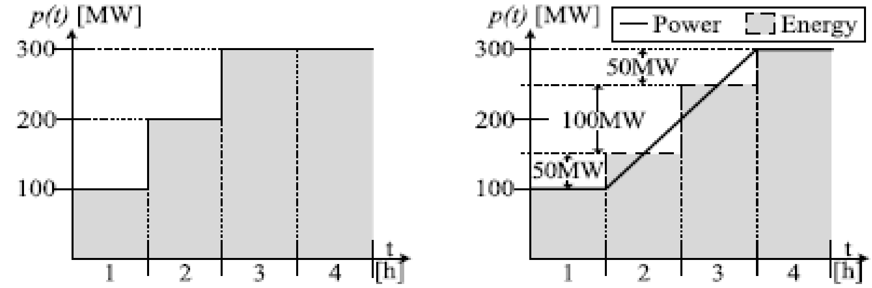
This section presents the main characteristics of the model used in this. It should be noted that this state- state-of-art UC model is a ramp-based scheduling model (denoted as RmpSch) and the conventional UC model is an energy block model (denoted as EnSch).

3.1.1. Remarks on UC model

In the literature review, two different scheduling approaches of UC-based MC are identified, namely Ensch and RmpSch. In the increasingly uncertain electricity market, the DAM scheduling approaches are required to efficiently manage the power system flexibility by adequately utilizing ramping resources. From this angle, this section presents main drawbacks of the conventional UC approach and explains how the later approach proposed in [7] could overcome these challenges and hence is taken to be the UC model to apply in this work.

Conventional energy-block UC approach seeks to provide an energy demand profile at minimum cost. In which the energy demand profile is represented using energy levels in a stepwise fashion and all constraints involving generating limits are imposed to these energy levels [21]. As addressed in [22], the most important drawbacks of this conventional approach in capturing the real operating activities of thermal units are infeasibility operating schedule, overlook of startup (SU) and shutdown (SD) power trajectories and issue with reserve modeling. These drawbacks influence directly the result for obtained marginal cost.

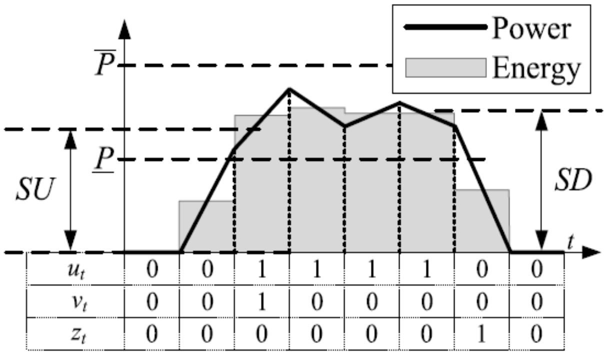
Firstly, the realization of Ensch schedule could not be guaranteed as it may violate the ramping constraints, hence it does not capture the maximum operating flexibility of thermal units in reality. An example taken from [23] and depicted in Figure 3.1 is used to illustrate this drawback, in which the output level is calculated at the end of each hour. In reality, a generating unit with maximum (minimum) output of 300 (100) MW and a ramping limit of 100 MW/ h could not reach the level of 300 MW until the end of hour 2 as illustrated in Figure 3.1(b). However, the conventional energy scheduling shown in Figure 3.1(a) has not taken the ramping limit into consideration and resulted in an infeasible operating schedule.



(a) Traditional Energy Schedule (b) Actual Deployment

Figure 3.1: Scheduling vs. actual deployment. Source:[7]

Secondly, Ensch scheduling often ignores the SU and SD power trajectories with the presumption that generators could startup or shutdown at their minimum production level. Hence the output does not include the power generated during these processes. Especially with large-scale integration of renewable energy, thermal units are required to SU and SD more often [8]. Consequently, the total energy lost is even more amplified. Finally, the conventional UC approach models the reserve constraint as an hourly requirement but not on the basis of its actual deployment time (e.g., 15 min) [20]. Hence the real reserve availability, which depends on actual ramp schedule, is not modeled realistically.



u_t	0	0	1	1	1	1	0	0
v_t	0	0	1	0	0	0	0	0
z_t	0	0	0	0	0	0	1	0

Figure 3.2: Unit's operation under the ramp-based scheduling approach. ***Source:[7]***

The ramp-based scheduling approach proposed in [7] draws a clear distinction between power and energy and the operating ramping of generators is optimally scheduled to supply an instantaneous power demand forecast as shown in Figure 3.2. The ramp constraints are thus applied on power trajectories rather than on energy blocks, which could avoid the first drawback of scheduling infeasibility. Furthermore, RmpSch also includes the SU & SD power trajectories of generators, thus avoiding power discontinuities in the scheduling stage and capturing properly the energy produced during such maneuvers as in the case of Ensch. In addition, regarding the third drawback, the proposed formulation provides the actual ramp schedules, and thus defines the available ramp capability that could be used to provide reserves. Although the formulation is based on a time period of one hour, it is also guaranteed that reserves can be deployed within the time requirements of a few minutes imposed by the MO and TSO.

It can be seen from this discussion that the ramp-based scheduling UC model outperforms the traditional energy block approach with a mode adequate system representation. Thus, this thesis work has been inspired and built based on this new approach proposed in [7] with the detailed formulation presented in the next section.

3.1.2. Ramp based scheduling approach

This section details the mathematical formulation of the UC model adopted from [7]. Regarding operating reserves, it is noted that both European and U.S. standard could be used as a benchmark by changing the reserve time deployment parameters (t_{sec} and t_{ter} defined below). The up reserve is defined as the amount of power that the unit could increase over its scheduled power output within a time limit, and vice versa for the down reserve. Secondary reserves are provided by online units that are in response to the continuous automatic generation control (AGC), this must be fully available within t_{sec} minutes (e.g., 15 minutes for European standards and 10 minutes for U.S. standards). Tertiary reserves are provided by both online and offline units. They are controlled by the TSOs and used to restore an adequate level of secondary reserve.

The formulation also considers different ramp limits to model different reserve time deployment: the shorter the deployment time requires, the larger ramp limits without shortening the rotor life [23]. For simplicity, a constant ramp late during the *up* state is assumed; a work with dynamic operating ramp rate could be done in a further study.

3.1.2.1. Nomenclature

Nomenclatures used in this work are summarized in Table 3.1, which includes definitions, indexes and sets, parameters and decision variables.

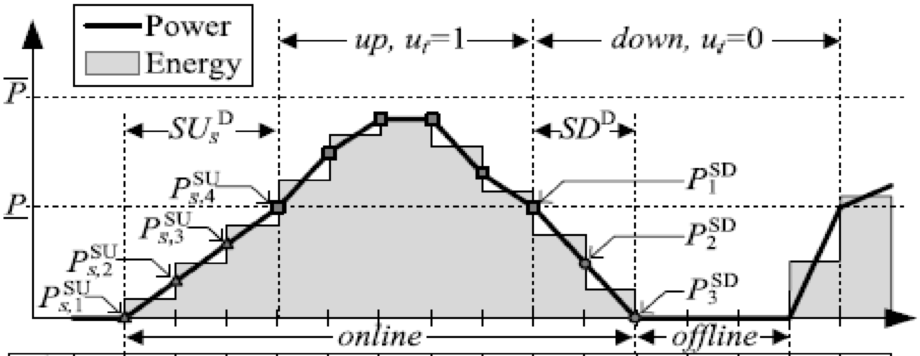
Table 3.1: Nomenclature of UC model

NOMENCLATURE	DESCRIPTION	UNIT
	Definitions	
online	Unit is synchronized with the system	
offline	Unit is not synchronized with the system	
up	Unit is producing above its minimum output and below its maximum output. During the up state, the unit output is controllable	
down	Unit is producing below its minimum output. During the down state, the unit is either offline or SU/ SD	
	Indexes and Sets	
$\boldsymbol{g} \in \boldsymbol{G}$	Generating units, running from 1 to $\boldsymbol{G}$	
$\boldsymbol{l} \in \boldsymbol{S}(\boldsymbol{g})$	Start-up type, running from $\boldsymbol{l}$ (the hottest) to $\boldsymbol{S}(\boldsymbol{g})$ (the coldest)	
$\boldsymbol{p} \in \boldsymbol{P}$	Hourly periods, running from 1 to $\boldsymbol{P}$ hours	
$\boldsymbol{tg}$	Type of generators	
$\boldsymbol{quick}(\boldsymbol{g})$	Set of quick-start units	
	Scalar	
$\boldsymbol{c_{ens}}$	Cost of unserved power	[$/ MWh]
$\boldsymbol{c_{rns}}$	Cost of unserved reserve	[$/ MWh]

p_{ini}	First period	
p_{fin}	Last period	
t_{sec}	Secondary reserve deployment time	[min]
t_{ter}	Tertiary reserve deployment time	[min]
Parameters - Initial conditions:		
$u_0(g)$	Initial unit commitment	
$q_0(g)$	Power produced of unit g prior to the scheduling horizon	[MW]
$q_{01}(g)$	Power produced of unit g prior to the scheduling horizon that above minimum output	[MW]
$TU_0(g)$	Number of hours that unit g has been up prior scheduling horizon	[h]
$TD_0(g)$	Number of hours that unit g has been down prior scheduling horizon	[h]
$TU_R(g)$	Number of hours during which unit g must remain up at the beginning of the scheduling horizon	[h]
$TD_R(g)$	Number of initial h during which unit g must remain down at the beginning of the scheduling horizon	[h]
Parameters – Operating costs		
$LV_{cost}(p,g)$	Linear variable production cost at period p of unit g	[$/ MWh]
$NL_{cost}(g)$	No load cost of unit g	[$/ h]
$SD_{cost}(g)$	Shut down cost of unit g	[$]
$SU_{cost}(g,l)$	Start-up cost of type l of unit g	[$]
$r^+_{2,cost}(p,g)$	Secondary reserve up cost at period p of unit g	[$/ MWh]
$r^-_{2,cost}(p,g)$	Secondary reserve down cost at period p of unit g	[$/ MWh]
$r_{3,cost}(p,g)$	Tertiary reserve cost at period p of unit g	[$/ MWh]
$r_{N3,cost}(p,g)$	Offline tertiary reserve cost at period p of unit g	[$/ MWh]
Parameters – Operating limits		
$q_{max}(g)$	Maximum output of unit g	[MW]
$q_{min}(g)$	Minimum output of unit g	[MW]
$RU_{hour}(g)$	Operation ramp up of unit g	[MW/ h]
$RD_{hour}(g)$	Operation ramp down of unit g	[MW/ h]
$RU_{sec}(g)$	Ramp up capability to provide secondary reserve of unit g	[MW/ t_sec]
$RD_{sec}(g)$	Ramp down capability to provide secondary reserve of unit g	[MW/ t_sec]
$RU_{ter}(g)$	Ramp up capability to provide tertiary reserve of unit g	[MW/ t_ter]
$RD_{ter}(g)$	Ramp down capability to provide tertiary reserve of unit g	[MW/ t_ter]
$q^{SU}_{hour}(g)$	Quick start-up capacity per hour of unit g	[MW]
$q^{SD}_{hour}(g)$	Quick shut down capacity per hour of unit g	[MW]

$q_{ter}^{SU}(g)$	Quick start-up capacity per t_{ter} of unit g	[MW]
$q_{ter}^{SD}(g)$	Quick shut down capacity per t_{ter} of unit g	[MW]
$TD(g)$	Minimum down time of unit g	[h]
$TU(g)$	Minimum up time of unit g	[h]
$SU(g,l)$	Duration of the startup type l of unit g	[h]
$SD(g)$	Duration of the shutdown of unit g	[h]
$t_{min}^{SU}(g,l)$	Minimum number of hours that the unit must be down to qualify for start-up type l of unit g	[h]
$q_{SD}(g,i)$	Power output at the beginning of the i-th interval of the SD ramp process of unit g	[MW]
$q_{SU}(g,l,j)$	Power output at the beginning of the j-th interval of the SU ramp process of start-up type l of unit g	[MW]
Parameters – System factors		
$wg(p)$	Wind power output at period p	[MW]
$D(p)$	Load demand at period p	[MW]
$D_{sec}^{+}(p)$	Up secondary reserve demand at period p	[MW]
$D_{sec}^{-}(p)$	Down secondary reserve demand at period p	[MW]
$D_{ter}^{+}(p)$	Up tertiary reserve demand at period p	[MW]
$D_{ter}^{-}(p)$	Down tertiary reserve demand at period p	[MW]
Decision variables – Positive variables		
$e(p,g)$	Total energy production during period p including SU and SD processes at period p of unit g	[MWh]
te	Total energy produced in the study period	[MWh]
$q(p,g)$	Total power output schedule at the end of hour p including SU and SD trajectories of unit g	[MW]
$q_1(p,g)$	Power output schedule at the end of hour p that above minimum output of unit g	[MW]
$p_{ns}(p)$	Non-served power at the end of period p	[MW]
$p_{ex}(p)$	Excess of produced power at the end of period p (to avoid infeasibilities of equations)	[MW]
$r_2^{+}(p,g)$	Up secondary reserve at period p of unit g	[MW]
$r_2^{-}(p,g)$	Down secondary reserve at period p of unit g	[MW]
$r_3^{+}(p,g)$	Up tertiary reserve at period p of unit g	[MW]
$r_3^{-}(p,g)$	Down tertiary reserve at period p of unit g	[MW]
$r_{N3}^{+}(p,g)$	Up offline tertiary reserve at period p of unit g	[MW]
$r_{N3}^{-}(p,g)$	Down offline tertiary reserve at period p of unit g	[MW]
Decision variables – Binary variables		
$u(p,g)$	Binary variable which is equal to 1 if at period p, unit g is producing above q_{min} and 0 otherwise, ***see Fig. 3.3***	

$\boldsymbol{y}(\boldsymbol{p},\boldsymbol{g})$	Binary variable which is equal to 1 if at period $\boldsymbol{p}$, unit $\boldsymbol{g}$ starts up and 0 otherwise, see Figure 3.3	
$\boldsymbol{z}(\boldsymbol{p},\boldsymbol{g})$	Binary variable which is equal to 1 if at period $\boldsymbol{p}$, unit $\boldsymbol{g}$ shuts down and 0 otherwise, see Figure 3.3	
$\boldsymbol{u}^{+}_{\boldsymbol{N3}}(\boldsymbol{p},\boldsymbol{g})$	Binary variable which is equal to 1 if at period $\boldsymbol{p}$, unit $\boldsymbol{g}$ is providing up offline tertiary reserve and 0 otherwise	
$\boldsymbol{u}^{-}_{\boldsymbol{N3}}(\boldsymbol{p},\boldsymbol{g})$	Binary variable which is equal to 1 if at period $\boldsymbol{p}$, unit $\boldsymbol{g}$ is providing down offline tertiary reserve and 0 otherwise	
$\Delta(\boldsymbol{g},\boldsymbol{p},\boldsymbol{l})$	Binary variable which is equal to 1 if at period $\boldsymbol{p}$, unit $\boldsymbol{g}$ has start-up style $\boldsymbol{l}$ and 0 otherwise	



t [h]	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
u_t	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	1
v_t	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
w_t	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0

Figure 3.3: Unit operation states, including SU and SD power trajectories Source : [7]

3.1.2.2. Objective function

The objective from a SO's point of view is to provide energy and reserve at the minimum cost, while satisfying all the technical constraints and keeping an adequate security level. The total costs consist of providing reserve, start-up cost, shut down cost, no load cost, variable production cost, non-served energy cost and non-served reserve cost. In particular, the start-up cost has two cost components, first to bring the thermal unit online and does not produce any energy [7] and second to produce energy during the SU process starting from 0 to its minimum output. Both two costs depend on how long the unit has been offline [8]. Likewise, the shutdown cost is the cost of producing energy during the SD process starting from its minimum output to 0. Hence, the objective function to be minimized is as equation (3.1) below:

$$\boxed{\begin{aligned}\sum_{\forall g}\sum_{\forall p}\Bigg[& r_{2,cost}^{+}(p,g) * r_{2}^{+}(p,g) + r_{2,cost}^{-}(p,g) * r_{2,cost}^{-}(p,g) + r_{3,cost}(p,g) \\ & * \left(r_{3}^{+}(p,g) + r_{3}^{-}(p,g)\right) + r_{N3,cost}(p,g) * \left(r_{N3}^{+}(p,g) + r_{N3}^{-}(p,g)\right) \\ & + \sum_{\forall l}\left[SU_{cost}(g,l) * \Delta(g,p,l)\right] + SD_{cost}(g) * z(p,g) + NL_{cost}(g) \\ & * u(p,g) + LV_{cost}(p,g) * e(p,g) + c_{ens} * (non\ served\ power)\Bigg] \qquad (3.1)\end{aligned}}$$

Note that the no-load cost (NL_{cost}) considered in objective function (3.1) ignores the SU & SD periods since it only multiples the commitment decision during the up state [24]. In order to consider the no-load cost during the SU & SD period, the SU & SD costs are defined as:

$$SU_{cost}(g,l) = SU'_{cost}(g,l) + NL_{cost}(g) * SU(g,l), \qquad \forall g,l \tag{3.2}$$

$$SD_{cost}(g) = SD'_{cost}(g) + NL_{cost}(g) * SD(g,l), \qquad \forall g,l \tag{3.3}$$

3.1.2.3. Constraints

Constraints used in the proposed UC formulation under the ramp-based scheduling approach are presented in this section. The first part of this section presents the general formulation as in most UC models. The second part describes how to obtain the ramp-capability and power-capacity constraints using the proposed ramp-based scheduling approach. The following two parts are devoted to modeling the reserve constraints for slow start units and quick start units (which can startup within one hour) respectively. Finally, the last subsection details how should the initial conditions prior to the scheduling horizon be set.

A. General constraints

As shown in Figure 3.3, different operating states of thermal units are distinguished, i.e., up and down states vs. online and offline states, in order to be able to model the

SU and SD power trajectories. The generation outputs above and below $\boldsymbol{q_{min}}$ are managed independently. During the up period above $\boldsymbol{q_{min}}$, the unit has the flexibility to follow any trajectory bounded by its power capacity and ramp limits. On the other hand, when producing below $\boldsymbol{q_{min}}$, the unit is either offline with 0 Mw output or following SU/ SD with predefined power trajectories. General constraints as in most of UC models are presented in this section.

Load Demand and Reserve Requirements

$$\sum_{\forall g}[q(p,g)+wg(p)+p_{ns}(p)-p_{ex}(p)]=D(p)\,,\forall p \tag{3.4}$$

$$\sum_{\forall g} r_2^+(p,g) \;\geq D_{sec}^+(p),\ \forall p \tag{3.5}$$

$$\sum_{\forall g} r_2^-(p,g) \geq D_{sec}^-(p)\,,\forall p \tag{3.6}$$

$$\sum_{\forall g}[r_2^+(p,g)+r_3^+(p,g)+r_{N3}^+(p,g)] \geq D_{sec}^+(p)+D_{ter}^+(p), \qquad \forall p \tag{3.7}$$

$$\sum_{\forall g}[r_2^-(p,g)+r_3^-(p,g)+r_{N3}^-(p,g)] \geq D_{sec}^-(p)+D_{ter}^-(p), \qquad \forall p \tag{3.8}$$

The load demand constraints, represented by their instantaneous power trajectories, equation (3.4) is calculated at the end of the hour p. Notice that the energy balance within the hour p is automatically achieved by satisfying the condition at the end of hour (p-1) and at the end of hour (p). It should be noted that the value of dual variable ($/ MW) from this constraint will be used as an estimate of the marginal cost ($/ MWh). That is the only interpretation of the dual variable.

The requirements for up and down secondary reserves are shown in equation (3.5) and (3.6). Meanwhile, regulation and operating reserves have the property of 'hierarchical substitution', meaning that a higher quality reserve (secondary reserve) can substitute for lower quality reserve (tertiary reserve) as long as the total procurement cost decreases [19]. This fact is represented in equation (3.7) and (3.8).

Commitment Logic and Minimum Up/Down Times

$$u(p,g) - u(p-1,g) = y(p,g) - z(p,g), \qquad \forall p,g \tag{3.9}$$

$$\sum\nolimits_{i=p-TU(g)+1}^{p} y(p,g) \leq u(p,g) \ \forall g,p \in [TU(g),P] \tag{3.10}$$

$$\sum\nolimits_{i=p-TD(g)+1}^{p} w(p,g) \leq 1 - u(p,g) \ \forall g,p \in [TD(g),P] \tag{3.11}$$

Equation (3.9) shows the relationship between the commitment decisions, start up and shut down variables. Equation (3.10) ensures the minimum up time of a generating unit, so they cannot shut down unless they have been online for at least $TU(g)$ periods. The same logic applies to equation (3.11) with the minimum number of down time periods.

Selection of SU type

$$\Delta(g,p,l) \leq \sum\nolimits_{i=t_{min}^{SU}(g,l)}^{t_{min}^{SU}(g,l+1)-1} w(p-i,g), \forall g,l,p \in \left[t_{min}^{SU}(g,l+1),P\right] \tag{3.12}$$

$$\sum_{\forall l} \Delta(g,p,l) = y(p,g)\,,\forall p,g \tag{3.13}$$

As defined earlier, this study considers different types of startups according to how many hours the unit has been offline. Equation (12) allows the startup type l can be selected ($\Delta(g,p,l) \leq 1$) if the unit has been previously down within $[t_{min}^{SU}(g,l), t_{min}^{SU}(g,l+1)]$ hours. Constraint (3.13) forces a unique selection of only one type of SU if the unit actually starts up.

Quick-start units are units that could ramp up from 0 to more than q_{min} or ramp down from above q_{min} to 0 within one hour. Hence by default their startup time is one hour. The power and energy output of quick-start units will be simpler than that of slow-start units and will be shown in section C. The following equation (3.14) is therefore applicable only to slow-start units.

Total Power Output for slow-start units

$$
\begin{aligned}
q(p,g) = \sum_{\forall l} \sum_{i=1}^{SU(g,l)} & [q_{SU}(g,l,j) * \Delta\,(g, p - i + SU(g,l) + 2) \\
& + \sum_{i=2}^{SD(g,l)+1} q_{SD}(g,i) * z(p - i + 2, g) + q_{min}(g) * (u(p,g) + y) \\
& + q_1(p,g)], \quad \forall p, g \qquad (3.14)
\end{aligned}
$$

Even though all technical constraints, e.g., operating ramp limits, capacity constraints, presented are applied to $q_1(p,g)$, which is defined as the power above the minimum output. The total power $q(p,g)$, which includes both SU and SD processes, are the actual value that needs to satisfy the demand constraints as shown in equation (3.4). Equation (3.14) includes explicitly three main components as follows:

- The first two components are the outputs during the SU and SD processes as depicted in Figure 3.3
- The last term is the output when unit is up

Energy Schedule

$$
e(p,g) = q_{min}(g) * u(p,g) + \frac{q_1(p,g) + q_1(p-1,g)}{2}, \qquad \forall p, g \qquad (3.15)
$$

As explained in the objective function, the cost of produced energy during SU and SD periods has been internalized into the SU and SD costs. Hence equation (3.15) only presents the energy generated during the up state in order to calculate the unit's production cost in the objective equation (3.1). In addition, the total energy produced including SU and SD could be easily obtained with the total power produced $q(p,g)$ after the optimization problem is solved.

Operating Ramps

$$
RD_{hour}(g) \leq q_1(p,g) - q_1(p-1,g) \leq RU_{hour}(g), \qquad \forall p, g \qquad (3.16)
$$

The typical conventional ramping limits in equation (3.16) are applicable during the up period and hence to $q_1(p,g)$ (the output above q_{min}), because in other segments, the output is either 0 or follows the predefined SU and SD trajectories.

B. Secondary and tertiary reserves for slow-start units

This section presents the complete formulation for secondary and tertiary reserves constraints of slow-start units, which includes two main aspects: ramping limits and capacity limits. Figure 3.4, for illustration purpose, shows the relationship between upward reserves, power trajectories and ramps according to European Standards with t_{ter} equal to 30 minutes and t_{sec} equal to 15 minutes, further mathematical explanations are in following equations.

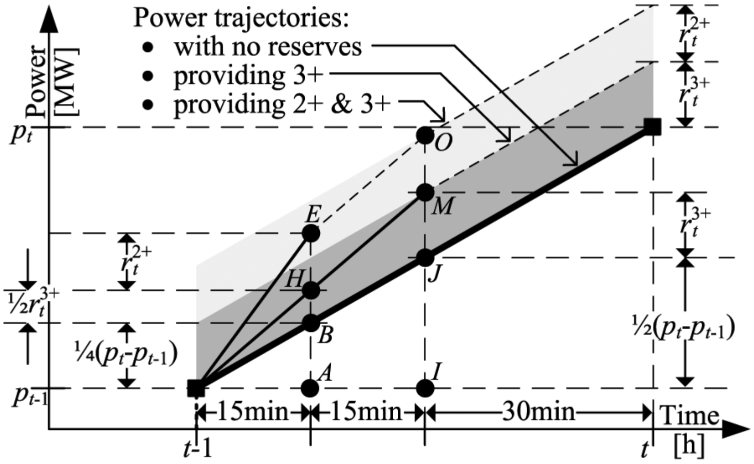


Figure 3.4: Relation between upward reserves, power trajectories and ramps (European standards). ***Source:[7]***

Ramping Limits

In general, the simultaneous deployment of secondary and tertiary reserves cannot exceed the ramping limits. Constraints (3.17) and (3.18) ensure that the unit operates within its t_{ter} ramp limit (i.e., 30 minutes in European standards in Figure 3.4) and equations (19) and (20) ensures the operation within the unit's t_{sec} ramp limits (i.e., 15 minutes in European standards in Figure 3.4). The letters in the following equations can be seen in the figure, and they are used to represent the line segments.

$$\underbrace{\underbrace{\frac{t_{ter}}{60} * \left(q_1(p,g) - q_1(p-1,g)\right)}_{JI} + \underbrace{r_3^+(p,g)}_{MJ}}_{MI} \leq \ RU_{ter}(g)\,, \qquad \forall p,g \tag{3.17}$$

$$\frac{t_{ter}}{60} * \left(q_1(p-1,g) - q_1(p,g)\right) + r_3^-(p,g) \leq \ RD_{ter}(g)\,, \qquad \forall p,g \tag{3.18}$$

$$\underbrace{\underbrace{\frac{t_{sec}}{60} * \left(q_1(p,g) - q_1(p-1,g)\right)}_{BA} + \underbrace{\frac{t_{sec}}{t_{ter}} r_3^+(p,g)}_{HB} + \underbrace{r_2^+(p,g)}_{EH}}_{EA} \leq \ RU_{sec}(g)\,, \qquad \forall p,g \tag{3.19}$$

$$\frac{t_{sec}}{60} * \left(q_1(p-1,g) - q_1(p,g)\right) + \frac{t_{sec}}{t_{ter}} r_3^-(p,g) + r_2^-(p,g) \leq \ RD_{sec}(g)\,, \qquad \forall p,g \tag{3.20}$$

More specifically, equation (3.17) means that the total ramp up excursion due to the sum of scheduled power trajectory (JI) and the up tertiary reserve (MJ) cannot exceed the t_{ter} ramp up limit. Likewise, in equation (3.19) the summation of ramp up due to the scheduled power trajectory (BA), possible up tertiary reserve (HB) and up secondary reserve (EH) cannot exceed the t_{sec} ramp limit. Equation (3.18) and (3.20) are the constraints for the downward reserve limits, which could easily be understood using the same logic.

Capacity Limits

$$q_1(p.g) + r_2^+(p,g) + r_3^+(p,g) \leq [q_{max}(g) - q_{min}(g)] * [u(p,g) - z(p+1,g)], \forall p,g \tag{3.21}$$

$$q_1(p.g) + r_2^-(p,g) + r_3^-(p,g) \geq 0, \forall p,g \tag{3.22}$$

Equation (3.21) and (3.22) ensure that the reserve intervals remain within the power capacity limits at the end of the hour. Equation (3.23) and (3.24) impose the same constraints for the power limits within the hour, especially for these maximum points at t_{sec} and t_{ter}, which are point O and E respectively in Figure 3.4.

$$\underbrace{\underbrace{\frac{t_{ter}}{60} * \left(q_1(p,g) + q_1(p-1,g)\right)}_{\boxed{J}} + \underbrace{r_2^+(p,g)}_{\boxed{OM}} + \underbrace{r_3^+(p,g)}_{\boxed{MJ}}}_{\boxed{O}} \leq q_{max}(g) - q_{min}(g), \ \forall p,g \tag{3.23}$$

$$\underbrace{\underbrace{\frac{t_{ter}}{60} * q_1(p,g) + \left(1 - \frac{t_{sec}}{60}\right) * q_1(p-1,g)}_{\boxed{B}} + \underbrace{r_2^+(p,g)}_{\boxed{FH}} + \underbrace{\frac{t_{sec}}{t_{ter}} r_3^+(p,g)}_{\boxed{HB}}}_{\boxed{E}} \leq q_{max}(g) - q_{min}(g), \ \forall p,g \tag{3.24}$$

Analogously, the following two equations ensure that the unit always producing its minimum output, which is guaranteed if the lowest value when providing both down secondary and tertiary reserves is greater than 0.

$$\frac{t_{ter}}{60} * \left(q_1(p,g) + q_1(p-1,g)\right) - r_2^-(p,g) - r_3^-(p,g) \geq 0, \quad \forall p,g \tag{3.25}$$

$$\frac{t_{sec}}{60} * q_1(p,g) + \left(1 - \frac{t_{sec}}{60}\right) * q_1(p-1,g) - r_2^-(p,g) - \frac{t_{sec}}{t_{ter}} r_3^-(p,g) \geq 0, \quad \forall p,g \tag{3.26}$$

In short, constraints in section B guarantee that the unit can provide simultaneously secondary and tertiary reserves at any time (beginning/ during/ end of the hour) without violating its ramping capability and power capacity.

C. Secondary and tertiary reserves for slow-start units

Unlike the slow-start units, quick-start units are able to ramp up from 0 to above q_{min} within an hour and vice versa for ramp down. This technically allows quick-start units to provide offline tertiary reserve and operating ramp limit will not be applicable for quick-start units. This section is dedicated to present the output for quick start units, introducing offline tertiary reserves and to ensure the operation of quick-start units within its capability

Total Power Output for Slow-start Units

$$q(p,g) = q_{min}(g) * u(p,g) + q_1(p,g), \qquad \forall p,g \tag{3.27}$$

Similar to equation 12 of total power output for quick-start units but in a simpler form since the SU and SD duration for quick-start units is an hour, equation (3.27) presents the total output for slow-start units.

Up and down offline tertiary reserves

$$q_{min}(g) * u_{N3}^{+}(p,g) \leq r_{N3}^{+}(p,g) \leq q_{ter}^{SU}(g) * u_{N3}^{+}(p,g), \qquad \forall p,g \tag{3.28}$$

$$q_{min}(g) * u_{N3}^{-}(p,g) \leq r_{N3}^{-}(p,g) \leq q_{ter}^{SD}(g) * u_{N3}^{-}(p,g), \qquad \forall p,g \tag{3.29}$$

Due to the minimum output q_{min}, the scheduled offline up reserve must be above q_{min} and below the t_{ter} quick-SU power capability ($q_{ter}^{SU}(g)$) of the unit as presented in equation (3.28). Similarly, the offline down reserve must be between q_{min} and below the t_{ter} quick- SD power capability ($q_{ter}^{SD}(g)$) as presented in equation (3.29). It is assumed that the tertiary offline down reserve involves the shutdown of the unit.

Furthermore, the following two equations ensure that the unit can provide offline up reserves if the unit is down but not when shutting down (3.30) and the unit must be up but not starting up to provide the offline down reserve (3.31). Refer back to Figure 3.3 for the different operating states of a thermal unit.

$$u_{N3}^{+}(p,g) + u(p,g) + z(p,g) \leq 1, \qquad \forall p,g \tag{3.30}$$

$$u_{N3}^{-}(p,g) - u(p,g) + y(p,g) \leq 1, \qquad \forall p,g \tag{3.31}$$

Capacity limits

In addition, capacity limits of quick units are imposed as an upper and lower bounds as below. In order to provide the offline down reserve for a given hour, the unit must be operating below the t_{ter} SD capability during that hour. This could be guaranteed by imposing the upper limit at the beginning of the hour (3.32) and at the end of the hour (3.33) below.

$$\begin{aligned} & q_1(p.g) + r_2^+(p,g) + r_3^+(p,g) \\ & \qquad \leq [q_{max}(g) - q_{min}(g)] * u(p,g) - [q_{max}(g) - q_{ter}^{SD}(g)] \\ & \qquad * u_{N3}^-(p+1,g) - \left[q_{max}(g) - q_{hour}^{SU}(g)\right] * y(p,g) \\ & \qquad - \left[q_{max}(g) - q_{hour}^{SD}(g)\right] * z(p+1,g), \qquad \forall p,g \end{aligned} \tag{3.32}$$

$$\begin{aligned} & q_1(p.g) + r_2^+(p,g) + r_3^+(p,g) \\ & \qquad \leq q_{max}(g) - q_{min}(g) - [q_{max}(g) - q_{ter}^{SD}(g)] * u_{N3}^-(p+1,g), \qquad \forall p,g \end{aligned} \tag{3.33}$$

The constraints are also imposed at minute t_{ter} (point 0 in Figure 3.4) and t_{sec} (point E in Figure 3.4) in equation (3.34) and (3.35) respectively.

$$\begin{aligned} & \frac{t_{ter}}{60} * \left(q_1(p,g) + q_1(p-1,g)\right) + r_2^+(p,g) + r_3^+(p,g) \\ & \qquad \leq q_{max}(g) - q_{min}(g) - [q_{max}(g) - q_{ter}^{SD}(g)] * u_{N3}^-(p,g), \qquad \forall p,g \end{aligned} \tag{3.34}$$

$$\begin{aligned} & \frac{t_{sec}}{60} * q_1(p,g) + \left(1 - \frac{t_{sec}}{60}\right) * q_1(p-1,g) + r_2^+(p,g) + \frac{t_{sec}}{t_{ter}} r_3^+(p,g) \\ & \qquad \leq q_{max}(g) - q_{min}(g) - [q_{max}(g) - q_{ter}^{SD}(g)] * u_{N3}^-(p,g), \qquad \forall p,g \end{aligned} \tag{3.35}$$

Finally, regarding the lower bound of capacity limit, the total power output must be greater than the summation of all possible downward reserves. In a similar manner as for the upper bound, this is ensured in the lower limit constraints of the unit at the beginning of the hour (3.36), at the end of the hour (3.37), at minute t_{ter} (equation 38), and at minute t_{sec} (3.39).

$$\begin{aligned} & q_1(p-1.g) - r_2^-(p-1,g) - r_3^-(p-1,g) - [r_{N3}^-(p,g) - q_{min}(g) * u_{N3}^-(p,g)] \geq 0, \\ & \qquad \forall p,g \end{aligned} \tag{3.36}$$

$$q_1(p.g) - r_2^-(p,g) - r_3^-(p,g) - [r_{N3}^-(p,g) - q_{min}(g) * u_{N3}^-(p,g)] \geq 0, \qquad \forall p,g \tag{3.37}$$

$$\begin{aligned} & \frac{t_{ter}}{60} * \left(q_1(p,g) + q_1(p-1,g)\right) - r_2^-(p,g) - r_3^-(p,g) - [r_{N3}^-(p,g) - q_{min}(g) * u_{N3}^-(p,g)] \\ & \qquad \geq 0, \qquad \forall p,g \end{aligned} \tag{3.38}$$

$$\frac{t_{sec}}{60} * q_1(p,g) + \left(1 - \frac{t_{sec}}{60}\right) * q_1(p-1,g) - r_2^-(p,g) - \frac{t_{sec}}{t_{ter}} r_3^-(p,g) - \left[r_{N3}^-(p,g) - q_{min}(g) * u_{N3}^-(p,g)\right] \geq 0, \qquad \forall p,g \tag{3.39}$$

D. Initial conditions

This UC approach includes different types of startups depending on how many hours the unit has been offline, hence there should be some constraints to define this decision ($\Delta(g,p,l)$) for these first hours before running the optimization model. As defined in [24], initial conditions of the operating schedule consists of two parts to satisfy the initial minimum up/ down times and to define the initial startup type.

Initial Minimum Up/Down times

The following parameters as defined in Nomenclature are presented here again in Table 3.2 for quick reference.

Table 3.2: Some relevant Nomenclature of UC model as per Table 3.1

Nomenclature	Description
$\boldsymbol{u_0(g)}$	Initial commitment status of the unit g
$\boldsymbol{TU_0(g)}$	Number of hours that the unit g has been up before the scheduling horizon
$\boldsymbol{TD_0(g)}$	Number of hours that the unit g has been down before the scheduling horizon
$\boldsymbol{TU_R(g)}$	Number of initial hour during which the unit must remain up at the beginning of the scheduling horizon
$\boldsymbol{TD_R(g)}$	Number of initial hour during which the unit must remain down at the beginning of the scheduling horizon

Following the description, $TU_R(g)$ and $TD_R(g)$ are obtained as follows:

$$TU_R(g) = MAX\{0, \left(TU(g) - TU_0(g)\right) * u_0(g)\} \tag{3.40}$$

$$TD_R(g) = MAX\{0, \left(TD(g) - TD_0(g)\right) * (1 - u_0(g))\} \tag{3.41}$$

When the unit has to remain online and offline for some initial periods ($TU_R(g)$ + $TD_R(g) \geq 1$), the unit commitment variables during these times must be fixed as in equation (3.42).

$$u(p,g) = u_0(g), \qquad \forall t \in [1, TU_R(g + TD_R(g)] \tag{3.42}$$

Initial Start-up type

Finally, when taking the initial conditions into consideration, if $TD_0(g) \geq 2$, startup decision should be fixed as follow for some initial periods:

$$\Delta(g,p,l) = 0, \qquad \forall l, p \in [t_{min}^{SU}(g, l+1) - TD_0(g), t_{min}^{SU}(g, l+1)] \tag{3.43}$$

All tests were carried out using CPLEX 12.4 under GAMS [62]. The problems were solved until they hit a CPU time limit of 10^9 second or when number of iterations exceeds 10^9 or until they reached optimality tolerance of 0.001. Apart from this, CPLEX default values were used for all the experiments. The problem is run using both Mixed Integer Programming (MIP) and Relaxed Mixed Integer Programming (RMIP) with CPLEX. The obtained dual variable of the demand balance equation from two approaches are denoted as EP_MIP and EP_RMIP respectively.

3.2. Econometric model

As in the second phase of the first task as proposed in Chapter 1, econometric models are used to derive a statistical connection between the obtained marginal cost from UC models and the real prices. The first part of this section provides an overview on the chosen econometric model, which is a multiple regression model. The second part presents the detailed description of the model with notations of explanatory variables.

3.2.1. Overview of the econometric model

To analyze market prices, there are many analyzing tools as mentioned in section 2.2 and they are in general effective to forecast future prices. However the relation between input and output variables is not clear, especially for nonlinear analysis. On the other hand, linear analysis is essential to show the connection between input and output variables. An important focus of this work is on the relationship between wind generation and electricity prices; hence the study focuses on a linear regression model. Furthermore, multi linear regression model (MLR) is an extended version of the simple single linear regression model, in which the coefficients of parameters are found based on principle of Least Squared: the model is fitted such that the sum of squared of the differences between observed and predicted values is minimized.

Secondly, regarding the explanatory variables used, it is important that the forecasting model is simple, accurate and convenient to use. In particular, it is necessary to identify the main independent variables that affect the prices most and should be able to obtain with high accuracy by (t-24) to predict the price at time t. As suggested in [25] of predicting market clearing prices in California, given that the dependent variable is the price at time t, there are three main explanatory variables used in this study: price at time (t-24), net load at time (t) and the squared of net load at time (t), in which the latter two components could be predicted with high accuracy at the time (t-24).

Further details of the econometric model are presented in the following section.

3.2.2. Model description

In this ramp-based scheduling approach, due to the presence of non-convex cost function, the issue of whether the obtained marginal cost could be equal to the real electricity prices is still open for discussion [7]. However, in an ideal perfect market, the prices should be equal to the marginal cost. Therefore, the marginal cost obtained the model and the analysis of the difference between both values would certainly provide interesting insights about the electricity prices and reveal useful information about market behavior. Hence, this study will analyze the mark-up under two possible definitions: the logarithmic difference of both value in equation (3.44) and Lerner index in equation (3.45), which is a well-known parameter used in economy theory to quantify the degree of competition in a market [25]. The econometrics analysis will be done for 3 types of models with different types of independent and dependent variables, namely purely time series model, pure UC model and hybrid models, as explained in details below.

To start with the model description, a list of explanatory variables used, which are identified to have a statistically significant correlation with prices [59] is summarized in Table 3.3. It is noted that as one of the objective of the work mentioned in Chapter 1, the econometrics regression model should be able to predict the real electricity market at least one day in advance. The study is conducted on an hourly basis; hence all the data of independent variables should be obtained at time (*t*-24) in advance to predict the electricity prices at time *t*.

Table 3.3: List of explanatory variables

Name	Description	Unit
Estimated P(t)	Final predicted electricity prices from the study	[$/ MWh]
P(t)	Real electricity price at time t	[$/ MWh]
P(t-24)	Yesterday's real electricity price at the same hour	[$/ MWh]
NL(t)	Net load at time t, which is equal to (demand - wind output), which could be forecasted a day in advance, given the current modern technology, the accuracy of the model should be high.	[MW]
M(t)	Mark up M(t), the logarithmic difference of the real price and model's marginal cost at time t, see equation (3.44)	
M(t-24)	Yesterday's markup M at the same hour	
L(t)	Mark up L of Lerner index at time t, see equation (3.45)	
L (t-24)	Yesterday's markup L at the same hour	
EP_MIP(t)	Marginal cost at time t obtained from the UC-Mixed Integer Linear Programming (MIP)	[$/ MWh]
EP_RMIP(t)	Marginal cost at time t obtained from the UC-Relaxed Mixed Integer Linear Programming (RMIP)	[$/ MWh]

$$M(t) = \log P(t) - \log(EP) \quad (3.44)$$

$$L(t) = \frac{P(t) - EP(t))}{P(t)} \quad (3.45)$$

As identified in literature, there are several price forecasting techniques, and amongst all, the hybrid approach proposed in [6] is considered the most interesting one when combining a fundamental engineering model with an econometric analysis. In order to assess the performance of this approach, other non-hybrid models, i.e., pure time series model and pure engineering UC model, should also be built and analyzed. Thus, a total of 3 types models will be studied and results will be compared in Chapter 6 to find the best model in terms of resembling the real prices.

First, a purely time series model is derived from historical data, where the predicted price at time *t* is a function of real price at the same time in previous day and the net load at time *t* as shown in equation (3.46).

Time series model:

$$Estimated\ P(t) = \alpha + \beta_1 * P(t-24) + \beta_2 * NL(t) + \beta_3 * [NL(t)]^2 \tag{3.46}$$

Second, two regression models using obtained theoretical prices from the UC MIP and UC RMIP models, noted as purely UC models shown in equation (3.47) and (3.48). In each of these two equation, the predicted price at time t is a function of the UC-model marginal cost at time *t* (either EP_MIP or EP_RMIP), real price at the same time in previous day and the net load at time *t*.

Purely UC models:

$$Estimated\ P(t) = \alpha + \beta_1 * EP\_MIP(t) + \beta_2 * P(t-24) + \beta_3 * NL(t) + \beta_4 * [NL(t)]^2 \tag{3.47}$$

$$Estimated\ P(t) = \alpha + \beta_1 * EP\_RMIP(t) + \beta_2 * P(t-24) + \beta_3 * NL(t) + \beta_4 * [NL(t)]^2 \tag{3.48}$$

The last models are called hybrid models, which consist of a total of 4 models resulting from two types of UC model (MIP and RMIP) and two types of mark-ups (mark up M and mark up L). The mark-up at time *t* is the dependent variable in the regression model as in equation (3.49) and (3.51), the independent variables are the mark-up at the same time on previous day and the net load at time *t*. Consequently, the predicted price is easily calculated from the estimated mark up using equation (3.50a) and (3.50b) for markup M, and equation (3.52a) and (3.52b) for mark-up L.

Hybrid models with M:

$$Estimated\ M(t) = \alpha + \beta_1 * M(t-24) + \beta_2 * NL(t) + \beta_3 * [NL(t)]^2 \tag{3.49}$$

$$Estimated\ P(t) = 10\text{^}(\log(EP\_MIP) + Estimated\ M(\mathrm{t}) \tag{3.50a}$$

$$Estimated\ P(t) = 10\text{^}(\log(EP\_RMIP) + Estimated\ M(\mathrm{t}) \tag{3.50b}$$

Hybrid models with L:

$$Estimated\ L(t) = \alpha + \beta_1 * L(t-24) + \beta_2 * NL(t) + \beta_3 * [NL(t)]^2 \tag{3.51}$$

$$Estimated\ P(t) = EP\_MIP/(1 - Estimated\ \ L(t)) \tag{3.52a}$$

$$Estimated\ P(t) = EP\_RMIP/(1 - Estimated\ \ L(t)) \tag{3.52b}$$

Furthermore, in a general framework of electricity price forecasting, other independent variables related to participant’s pricing strategies and production costs should also be considered. For future work, identifying some statistically significant explanatory variables are some possible interesting tasks.

4. SYSTEM DESCRIPTION AND PARAMETER DERIVATION

First section of this chapter presents an overview of the system of study, which is Electric Reliability Council of Texas (ERCOT) in Texas, U.S. The second part covers sources and derivation of input data of the study, both for UC model and econometric model.

4.1. ERCOT facts and test system description

Due to some difficulties in collecting and processing the limited available data, the completely accurate input parameters could not be obtained, and some realistic estimations have been introduced in order to make complete data set. The results obtained are then checked in Chapter 5 with the output validation.

4.1.1. Overview of ERCOT

ERCOT is one of 10 independent system operators (TSOs) and regional transmission organizations (RTOs) in North America who serves two-third of electricity consumers in the United States as well as more than 50% Canada's population [26]. As a TSO, ERCOT's mission is to "serve the public by ensuring a reliable grid, efficient electricity markets, open access and retail choice" [27].

As of May 2015, ERCOT system serves 24 million consumers, which makes up to 90% of total Texas's load. The ERCOT grid connects 43,000 circuit miles of high-voltages transmission and more than 550 generating units. ERCOT also manages financial settlement for the competitive wholesale bulk-power market and administers customer switching for more than 7 million premises in competitive choice areas. Energy consumption in 2014 was around 340 TWh, which is a 2.5 %

increase compared to 2013. The total market size is around $ 34 billion based on the 340 billion KWh market volumes and average $ 0.1/ kWh rate [28].

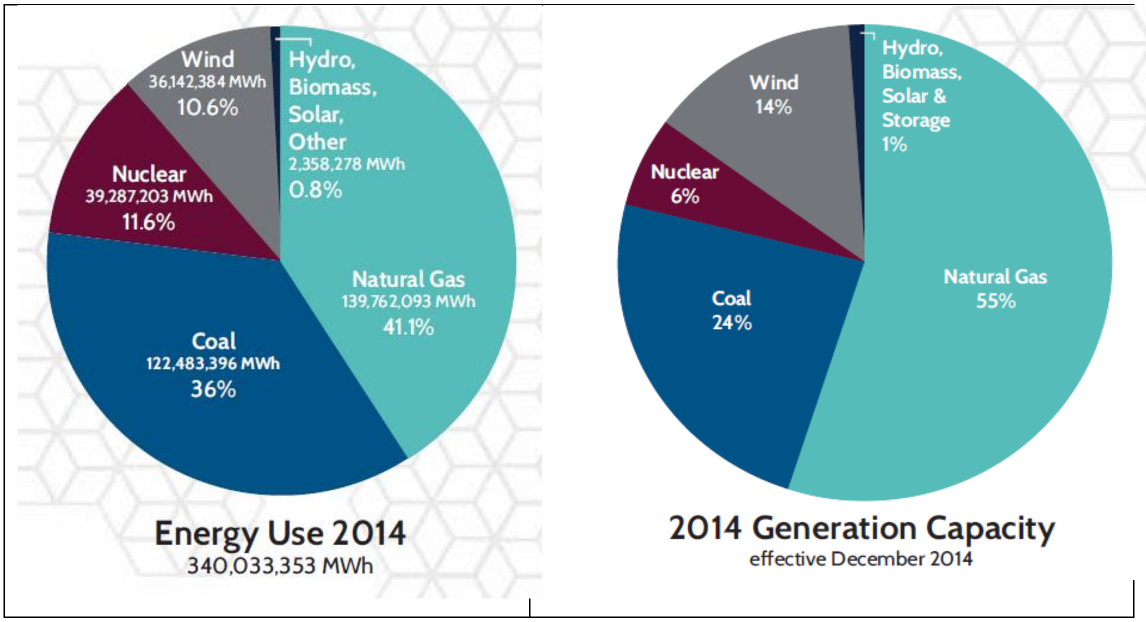


Figure 4.1: Energy use and generation capacity in 2014 of ERCOT system. Source: [29]

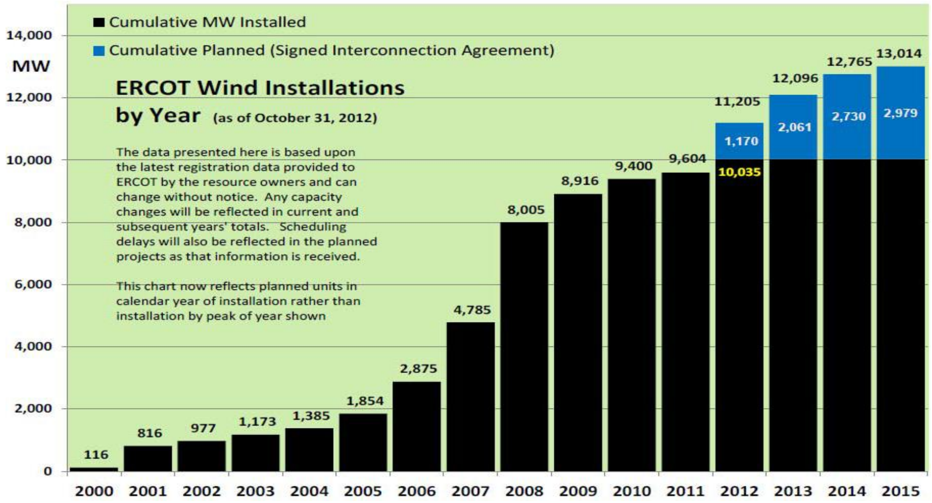


Figure 4.2: ERCOT wind generation by year. Source: [30]

ERCOT’s installed wind generation capacity is the highest among major ISOs in the United States with over 20% of the nation’s installed wind capacity, which was around 12,765 MW and made up 14% of total generation capacity in 2014 as observed from Figure 4.1 and Figure 4.2 [29][30]. On the other hand, the rapid increase of wind energy and its intermittence nature is imposing big challenges to system operation. In line with this fact, the study is dedicated to find the impact of wind generation on existing electricity network, through DAM electricity prices.

4.1.2. Remarks on ERCOT short-term planning

In a power system, a perfect continuous balance between supply and demand is always required prevent the system from collapsing. Any imbalance in real time must be readily absorbed by the available reserve. To guarantee this availability, not only the demand but also the reserve requirements must be committed in advance, usually a day-ahead, by solving the UC problem as described in Chapter 3.

In many electricity markets worldwide, electricity market is managed by the System Operator (SO), who structures the electricity market as DAM and a sequence of real-time markets (RTM) or intra-day markets. In contrast to the SO, the market operator (MO) operates an organized power exchange market on behalf of market participants. MO is only in charge of the economic transactions, and not on the system operation (like in most European systems). DAM in ERCOT is based on UC formulations of supplying demand at the minimum cost, where commitment decisions and market clearing prices for the next 24 hours are computed. In RTM, the market is run based on optimal economic dispatch (ED) in order to optimally manage the online units to meet demand at the lowest cost. Subsequently, the market settlement is based on deviations between DAM and RTM [31].

ERCOT system operates in a likewise manner as shown Figure 4.3. In December 2010, ERCOT successfully launched the locational marginal pricing based Nodal Market. The comprehensive nodal market includes congestion revenue right (CRR) auction market, a day-ahead market (DAM), reliability unit commitment (RUC) and real time security constrained economic dispatch (SCED). The focus of this work is DAM market, thus a detailed formulation of the UC model has been proposed earlier in chapter 3.

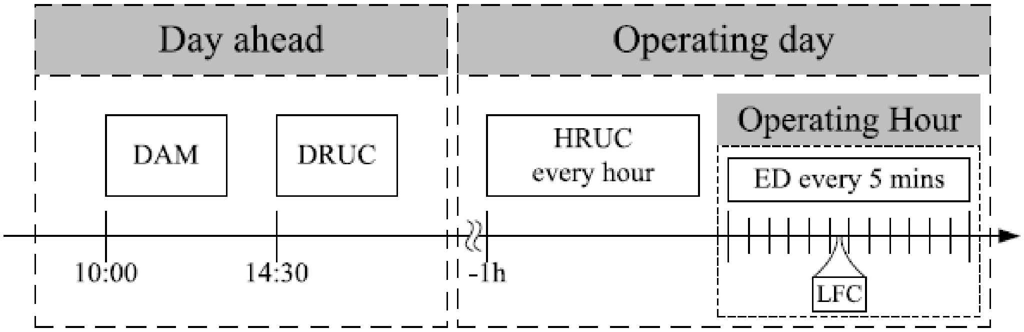


Figure 4.3: Short-term planning and operating practices in power systems in ERCOT system [7]

4.1.3. Test system description

Test system is considered from a single node approach, i.e., without modeling the network . The ERCOT power system consists of approximately 550 generating units. As shown in figure 4.1, roughly 85% of the whole generation capacity comes from thermal units, consisting of 296 generators. Wind farms make up around 14% of generation capacity in 2014, and are considered to have priority dispatch in this study, thus all wind generation will be dispatched first and treated as an input data for the UC model. Other types of generating units, e.g. hydro units, biomass, solar with a little importance of less than 1% of the system capacity are excluded in this work. Furthermore, there are 10 types of thermal generating units in ERCOT system categorized according to generating technology and their abbreviation used in this study follows the convention of ECORT and summarized in Table 4.1 for references[5].

Table 4.1: ERCOT thermal units abbreviations. Source: ERCOT

No.	ERCOT abbreviations	Unit Type
1	NUC	Nuclear
2	CLLIG	Coal and Lignite
3	CCGT90	Combined cycle greater than 90MW
4	CCLE90	Combined cycle less than or equal to 90MW
5	GSSUP	Gas-Steam Supercritical Boiler

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[5] http://mis.ercot.com/misapp/GetReports.do?reportTypeId=13424&reportTitle=Hourly%20Aggregated%20Wind%20Output&showHTMLView=&mimicKey

6	GSREH	Gas-Steam Reheat Boiler
7	SCGT90	Simple Cycle Greater than 90MW
8	GSNONR	Gas-Steam Non-reheat or boiler without air-preheater
9	SCLE90	Simply Cycle Less than or Equal to 90MW
10	DSL	Diesel

Figure 4.4 and Figure 4.5 below show the load demand and actual monthly peak demand based on hourly interval in ERCOT for 2014. It is observed that in August (period 5088 to 5831 in Figure 4.4:), demand is at its peak within the year, and its peak is the highest compared to other months (Figure 4.5). Furthermore, maintenance schedule of thermal units are usually done during the low demand period in April, May. Thus, given the available data of the whole system's installed capacity, August is the perfect time for the study when most of thermal units are operating and available to be dispatched, consequently the resulting UC dispatch should follow the merit order, where units with the lowest marginal cost are dispatched first. In chapter 5, model results will be validated to confirm this hypothesis.

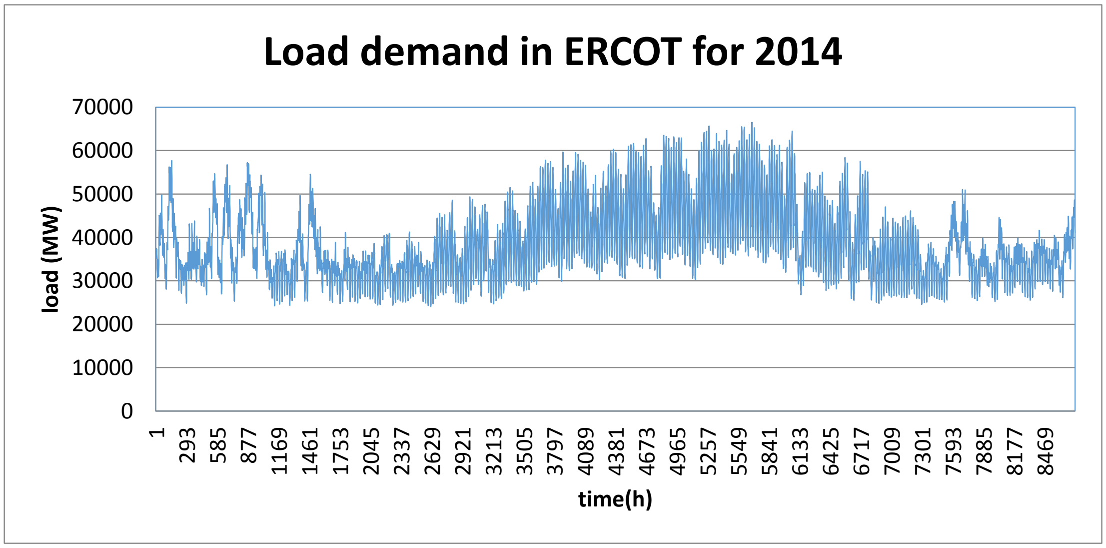

Figure 4.4: Load demand in ERCOT for 2014. Source: ERCOT

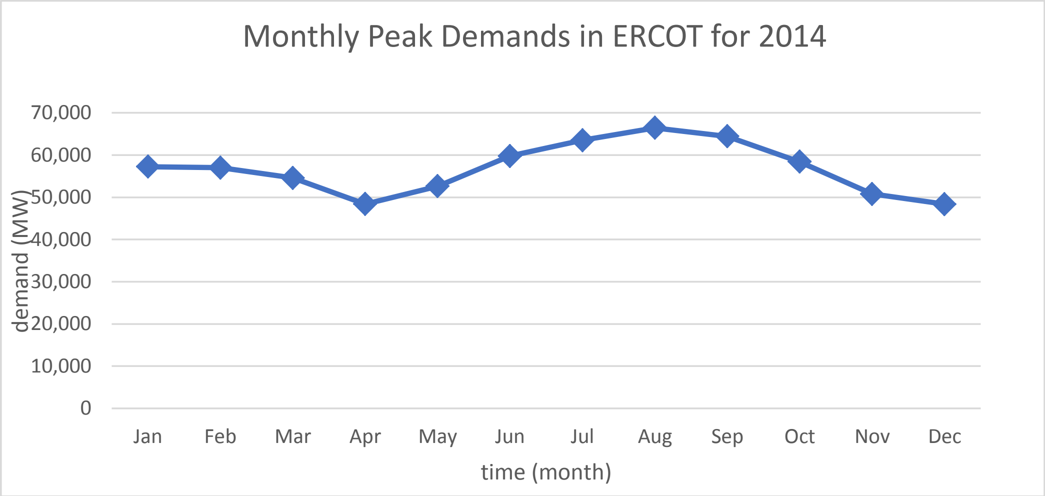

Figure 4.5: Monthly peak demands in ERCOT for 2014. Source: ERCOT

4.2. Data gathering and justification

This section describes how the data, which is implemented in the UC model as well as econometric model has been obtained. More specifically, data gathering for generators and the system parameters is presented below respectively.

In general, ERCOT official website is the main source of data for generator´s characteristics. In case of unavailability of required parameters, reasonable approximations are made. There are five main categories of data sources, namely: Protocol, Report or Presentation, Web Information, Journal paper or Dissertation and Personal Communication. Please refer to the reference section for more details.

4.2.1. Facility parameters

The notations of parameters presented in this section are consistent and organized in the same order with what defined for UC formulation in Chapter 3; please refer back to Table 3.1 for their complete definitions. This section covers facility parameters, which are grouped into three sets: Operating Costs, Operating Constraints and Initial Conditions.

4.2.1.1. Operating costs

As presented in the objective function in chapter 3, there are three main types of costs that thermal units have to bear, which are: no load and variable costs, SU & SD costs and cost of providing reserves.

No load costs and variable production costs

As defined in [32] no load cost is the hourly fixed cost, expressed in \$/ hr, required to create the starting point of a monotonically increasing incremental cost curve, i.e., the cost of total fuel to sustain 0 MW net output at synchronous generator speed. Variable production cost is defined as the cost per hour to operate a unit assuming a start has already occurred. In this study, the synchronous level is defined at the minimum output q_{min} for each generator. First, regarding the variable cost, among the 10 types of generating units in ERCOT, only NUC and CLLIG have a fixed variable production cost of 15 \$/ MWh and 18 \$/ MWh respectively. LV_{cost} of the rest are calculated using equation (4.1) [33] below and their heat rates are summarized inTable 4.2 [34]. It should be noted that the heat rate is based on the general heat rate used for Capacity Auction [60].

$$LV_{cost} = Equivalent\ Fuel\ Index\ Price\ (FIP) * Heat\ Rate \tag{4.1}$$

Table 4.2: Heat rates of different generating units. Source: [60]

No.	ERCOT abbreviations	Heat Rate[MBtu/MWh]
1	NUC	NA
2	CLLIG	NA
3	CCGT90	9
4	CCLE90	10
5	GSSUP	10.5
6	GSREH	11.5
7	SCGT90	14
8	GSNONR	14.5
9	SCLE90	15

10	DSL	16

The input data for fuel index price is taken from [35], which differs daily. This is shown in Table 4.3.

Table 4.3: Fuel Index Price in August 2014. Source: [35]

Date	FIP [$/MBtu]	Date	FIP [$/MBtu]
Aug 01, 2014	3.77	Aug 17, 2014	3.8
Aug 02, 2014	3.77	Aug 18, 2014	3.78
Aug 03, 2014	3.77	Aug 19, 2014	3.84
Aug 04, 2014	3.87	Aug 20, 2014	3.88
Aug 05, 2014	3.87	Aug 21, 2014	3.88
Aug 06, 2014	3.92	Aug 22, 2014	3.88
Aug 07, 2014	3.99	Aug 23, 2014	3.88
Aug 08, 2014	3.99	Aug 24, 2014	3.88
Aug 09, 2014	3.99	Aug 25, 2014	3.94
Aug 10, 2014	3.99	Aug 26, 2014	3.99
Aug 11, 2014	4	Aug 27, 2014	4.02
Aug 12, 2014	3.94	Aug 28, 2014	4.06
Aug 13, 2014	3.94	Aug 29, 2014	4.04
Aug 14, 2014	3.85	Aug 30, 2014	4.04
Aug 15, 2014	3.8	Aug 31, 2014	4.04
Aug 16, 2014	3.8		

Secondly, no-load cost could be derived from the variable cost, as shown in equation (2) below and illustrated in Figure 4.6 for a better understanding [33].

$$NL_{cost} = [min_{GenCost} - LV_{cost}] * Low\ Sustained\ Limit\ (LSL) \qquad (4.2)$$

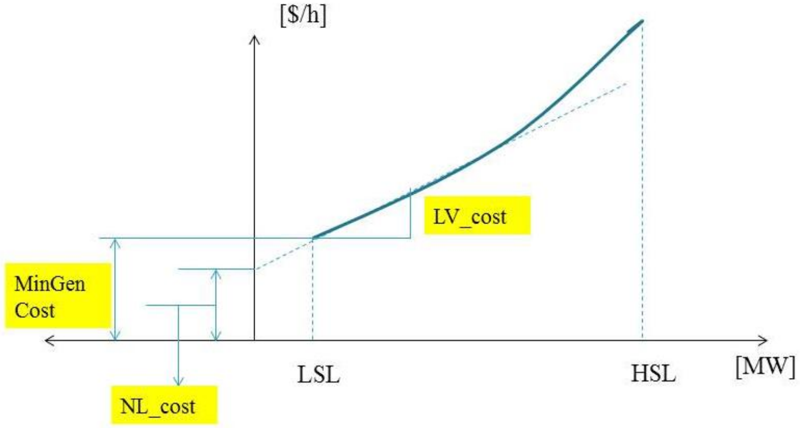

Figure 4.6: Approximation of no-load cost and variable cost

It is noted that parameters in Figure 4.6, which are Low Sustained Limit (LSL), and High Sustained Limit (HSL), are established by Qualified Scheduling Entity (GSE) to represent the minimum and maximum amount of available generation capacity in real time. Data are obtained from [36] and '60-Day SCED Disclosure' reports[6].

<u>*Start-up & Shutdown cost*</u>

Startup and shutdown cost represent the cost during the transition period between offline and online states as defined in Chapter 3. Taking as an instance of a steam turbine plant including a condenser, its interior consists of an upper space containing the tube bundle and the lower space containing the hot well. The startup is related to raising steam from primary energy in the lower space such as fossil fuel and the high pressure steam is fed to the turbine in the upper space and passes along the machine axis through multiple rows of alternatively fixed and moving blades[7]. At the shutdown of the steam turbine, the cost is associated with closing the isolation

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[6] mis.ercot.com/misapp/GetReports.do?reportTypeId=13052&reportTitle=60-Day SCED Disclosure&showHTMLView=&mimicKey

[7] http://www.mpoweruk.com/steam_turbines.htm

valve to isolate the upper space from the lower space while the lower space is maintained in vacuum[8].

More specifically, because the temperature and pressure of the thermal unit must be moved slowly, a certain amount of energy must be consumed to bring the unit on-line. This energy does not produce any MW generation, thus is referred to as a start-up cost in UC model [61]. The components of startup costs are fuel consumption rate and incremental O&M costs. Specifically, the first component is calculated as the fuel consumption rate per start (MMBtu/ start) multiplied by a resource category generic fuel price ($/ MMBtu) and the second one is unit-specific variable Within the ERCOT system, there are three types of start-ups associated with different start-up costs as described below [33].

- *Hot Startup cost*

  Hot startup cost is the expected cost to start a Resource, which is in the "hot" condition. Hot conditions vary unit by unit, but in general, a steam unit is hot through an overnight shutdown.
- *Intermediate Startup cost*

  Intermediate startup cost is the expected cost to start a Resource that has recently been online and for which neither hot nor cold conditions are applicable.
- *Cold Startup cost*

  Cold startup cost is the expected cost to start a resource, which is in the "cold" condition. Cold conditions vary unit by unit, but in general, a steam unit is cold after a two or three-day shutdown. In this thesis, for simplicity only the hot and cold startup types are considered, which are distinguished by the threshold *Tcold*.

Theoretically, values of start-up costs should be calculated in detailed according to equation (3.2) and (3.3). However, due to limited available data on the cost components, values used in this work are obtained from the generation data in

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[8] https://www.google.com.ar/patents/US5095706

[37] and from ERCOT ‘60-Day SCED Disclosure’ reports. Regarding the shutdown cost, it is treated in a conventional way in modeling of being equal to 0.

Reserve cost

There are 3 types of reserves considered in this study: secondary reserve, online tertiary reserve, and offline tertiary reserve. Due to the lack of available data on the actual cost of providing reserves, the value used in this work is a good approximation from [38] shown in Figure 4.7. Since it is hourly average prices of the month, thus the reserve cost at a particular hour is assumed to be the same every day throughout August. Figure 4.8 shows the final estimated data of the reserve costs, which is similar to Figure 4.7 with a flatter tail and high peak during the high demand hours from 4-5PM.

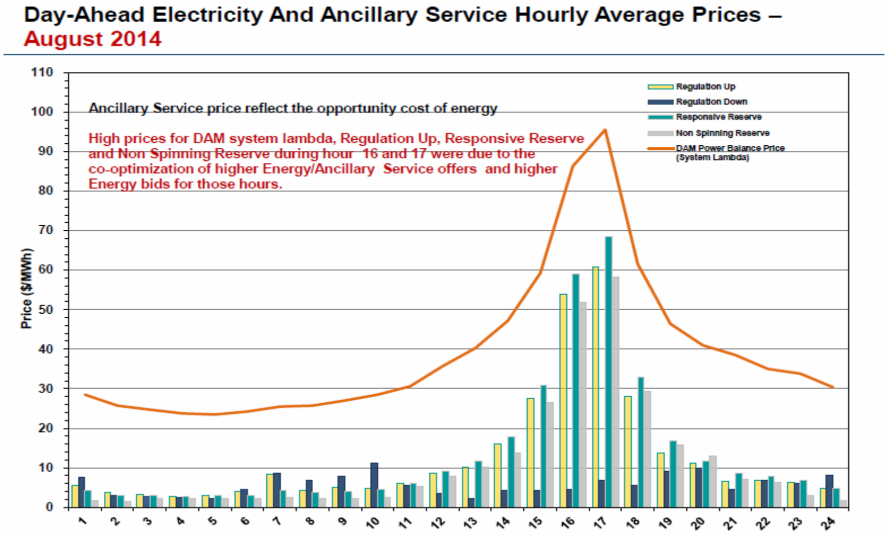

Figure 4.7: ERCOT day-ahead electricity and ancillary services hourly average prices, August 2014. Source: [38]

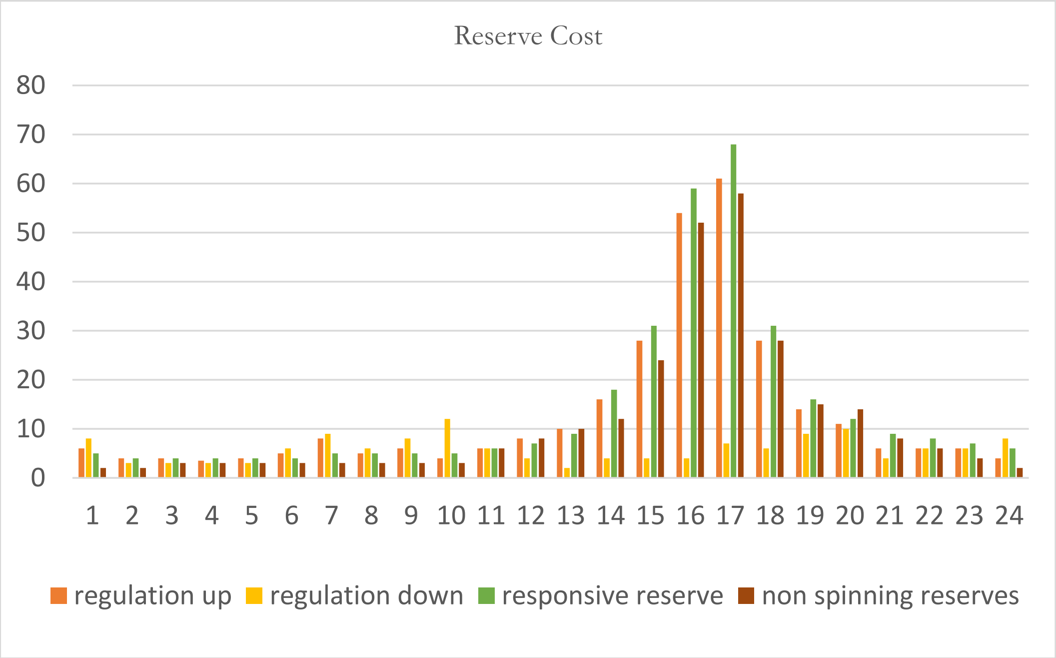

Figure 4.8: Reserve cost used in this thesis. Source: [38]

4.2.1.2. Operating constraints

Maximum/minimum output

Minimum and maximum real power output limits for all the generators (hereafter referred to as 'MaxProd' and 'MinProd') were obtained from [37] and ERCOT[9]. Certainly, unit production would not surpass its maximum value and it cannot go below the lower limits to ensure stable operations. This limit is usually given as a percentage of units' maximum production level

Operating ramp

There is a technical limitation with appropriate ramp rate for generating units to achieve a safe and sustainable operation. The ramp up and ramp down limits are not readily reported but are common data within a given technology group, these values are taken from [37]. Note that these parameters are operating ramping rates applied

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[9] http://mis.ercot.com/misapp/GetReports.do?reportTypeId=13051&reportTitle=60 Day DAM Disclosure Reports&showHTMLView=&mimicKey

to the power trajectories above q_{min} which are not applicable for the SU and SD periods.

Quick start capacity

As mentioned in chapter 3, different ramp limits to model different reserve time deployment are considered in the UC model, meaning that the shorter the deployment time requires, the larger ramp limits without shortening the rotor life [23]. For simplicity, as proposed in [24], the t_{sec} and t_{ter} ramp capabilities (15 min and 30 min in European standards) of the units are assumed to be equal to 150% and 100% of their operation ramp rates, respectively

Minimum up/down time

These parameters refer to the minimum time the unit has to be online once it starts up (TU) and the minimum time it has to be off (TD), once a shutdown occurs. During SU and SD, the unit is subjected to thermal stresses, which could lead to damage of the unit's component. TU typically is designed to minimize this thermal stress, which could otherwise arise [39]. TD requirement happen due to the thermal unit's intrinsic property. For instance, in the case of nuclear power plants, there is a technically mandated minimum down time of about 15 to 24 hours [40], or coal generating units have to stay offline to avoid boiler wear and damage [41]In this study, these minimum time requirements are obtained from '60-Day SCED Disclosure' reports on ERCOT official websites and from [37].

Startup (SU) & shutdown (SD) duration and Tcold

Different SU types depending on how many hours the unit has been offline will result in different SU duration. Since SU & SD durations are not explicitly publicly available, general data from [42] to [45] are used to make sensible estimations. It is noted that units are grouped by their technologies and within the same technology category, the SU and SD durations are constant.

SU durations:

As introduced in previous section, there are three types of SU: hot, intermediate and cold. However, for simplicity and lack of input data, only cold and hot SU have been modeled. Both types of start-up are differentiated by a threshold *Tcold*, i.e., if the offline time of unit exceeds *Tcold*, a cold SU is required and a hot SU otherwise. SU durations are defined as the time needed for the unit to increase its output from 0 to the minimum level q_{min}. The final values are taken from [37].

SD durations:

In general, it takes a shorter time for a unit to shutdown than to startup. There are two types of thermal units in the study: quick start units and slow start units. The calculation of these values are shown as follows [37]:

For quick-start units:

$$SD\ duration = \frac{cold\ SU\ duration + hot\ SU\ duration}{2} \tag{4.5}$$

For slow-start units:

$$SD\ duration = hot\ SU\ duration \tag{4.6}$$

As mentioned, *Tcold* is a threshold to distinguish hot and cold SU, which is different from one unit to another. They are estimated based on two values: minimum down time and hot SU duration. First, *Tcold* needs to be greater than the minimum down time; otherwise hot SU type will never be activated. Second, as the way of defining the operating state Figure 3.4 and objective function equation (3.1) in chapter 3, the cost of hot SU is only activated in the objective function when $\Delta(\boldsymbol{g},\boldsymbol{p},\boldsymbol{l})$ =1, which is only possible only if *Tcold* is greater than the hot SU duration. Consequently for simplicity, *Tcold* is set to be equal to the sum of minimum down time and hot SU duration.

Power output for SU and SD trajectories

Since for quick start units the SU and SD duration is 1 hour, this subsection is only applicable to slow start units. The power output for the SU power trajectories are obtained an hourly linear change from 0 to q_{min} and vice versa for SD for a duration of SU and SD hours. Shown in equations below:

$$q_{SD}(g,i) = q_{min}(g) - \frac{(i-1)q_{min}(g)}{SD(g)} \tag{4.7}$$

$$q_{SU}(g,l,j) = \frac{(j-1)q_{min}(g)}{SU(g,l)} \tag{4.8}$$

4.2.1.3. Initial conditions

As shown in Table 3.1, there are a total of seven parameters that define the initial conditions for each thermal unit. However, only data of four parameters, which are the unit commitment variable u_0 , power produced q_0 and number of hours that the unit has been up/ down (TU_0 / TD_0) prior to scheduling horizon, should be collected. This is because the other three would be easily obtained as followings, in which the first 2 equations are equations (3.38) and (3.39) from chapter 3.

$$TU_R(g) = MAX\{0, \left(TU(g) - TU_0(g)\right) * u_0(g)\} \tag{3.38}$$

$$TD_R(g) = MAX\{0, \left(TD(g) - TD_0(g)\right) * (1 - u_0(g))\} \tag{3.39}$$

$$q_{01}(g) = \begin{cases} 0, & if\ u_0(g) = 0 \\ q_0 - q_{min}, & if\ u_0(g) = 1 \end{cases} \tag{4.9}$$

As mentioned earlier in system description, the period of study is from August 1st 0.00 hrs (Friday) to August 31st, 13.00 hrs in 2014. To find the initial conditions, previous day's actual profiles are needed, which is Thursday. Since the electricity load as shown in Figure 4.4 possess a weekly pattern, i.e., the demand at the same hour on the same day does not differ much from one week to another, consequently so is the operating pattern of thermal units. The procedure to obtain the initial parameters:

- Set up a random but sensible initial condition of each unit, so that the demand is met and taking into account operating limits of units (q_{max}, q_{min})

- Run the model for 1-month period. To avoid any potential beginning and end effects of the scheduling horizon, the power output of Thursday at 23:00 hrs of the second week is chosen to be the initial condition of the study.

4.2.2. System parameters

Demand and wind load profiles for the month of august, 2014 are obtained from ERCOT website. For simplicity and since operating reserve is not the main focus of this study, its requirement is kept at a constant low percentage of the peak power demand (i.e., 1.5% of roughly 69,000 MW peak demand) within the scheduling horizon. For future work, a dynamic reserve requirements should be considered to have a more realistic view on the real market operation, which is also a current popular topic in the literature in order to deal with the large integration of renewable energy.

The obtained DAM prices are the average of 14 Hub Bus DAM prices in ERCOT system as shown in Figure 4.5. The Hub Bus prices for each hour of the settlement interval of the DAM are the simple average of the time weighted Hub Bus prices for each 15-minute settlement interval in real time [47].

Table 4.4: Hub Bus in ERCOT system. Source: ERCOT

Number	Hub Bus	Number	Hub Bus
1	HB_BUSAVG	8	LZ_CPS
2	HB_HOUSTON	9	LZ_HOUSTON
3	HB_HUBAVG	10	LZ_LCRA
4	HB_NORTH	11	LZ_NORTH
5	HB_SOUTH	12	LZ_RAYBN
6	HB_WEST	13	LZ_SOUTH
7	LZ_AEN	14	LZ_WEST

Data consistency is of utmost importance in this study. The complete data set is double checked to ensure coherence and logic. For instance, when running the optimization, each constraint is activated once at a time to observe if there is any unusual value. Taken as an example, regarding the initial conditions, q_0 has to be bounded by q_{max} and q_{min}, if u_0 is equal to 0, i.e., the unit is offline prior scheduling horizon, TD_0 has to be positive and TU_0 has to be 0.

5. RESULTS FROM UC MODEL

The main purpose of this chapter is to present the unit commitment dispatch using both MIP and RMIP approaches (Section 5.1), followed by output validation to confirm the validity of the obtained results (Section 5.2).

5.1. Unit commitment dispatch

The model has been run using both MIP and RMIP approach for a period of one month (744 hours) in August 2014, which is the peak period during summer month with the maximum energy demand (as illustrated in Chapter 4). This section presents the output and some remarks on the observations on the obtained marginal costs, real prices, and wind output.

It should be noted that in this study we are dealing with the UC problem, which is different from the traditional economic dispatch problem in the sense that it is no longer assumed that all units are committed [48]. In fact, the UC model's output consists of decisions regarding which units to commit and how much should they be producing. These will be summarized in section 5.1.1 and followed by section 5.1.2 with some comments on the model-estimated prices.

5.1.1. Generating schedule

As introduced in Chapter 4, there are 10 groups of thermal units consisting of around 300 generators in total in ERCOT System. Figure 5.1and Figure 5.2 below display the total output of each generating technology in the system during the month of August 2014, according to the merit order, i.e., the least expensive unit is used first. Detailed generation outputs could be found in Appendix A and B for MIP and RMIP models respectively. Also, the value of the objective function from MIP approach is approximately $1.48 billion compared to $1.47 billion from RMIP approach.

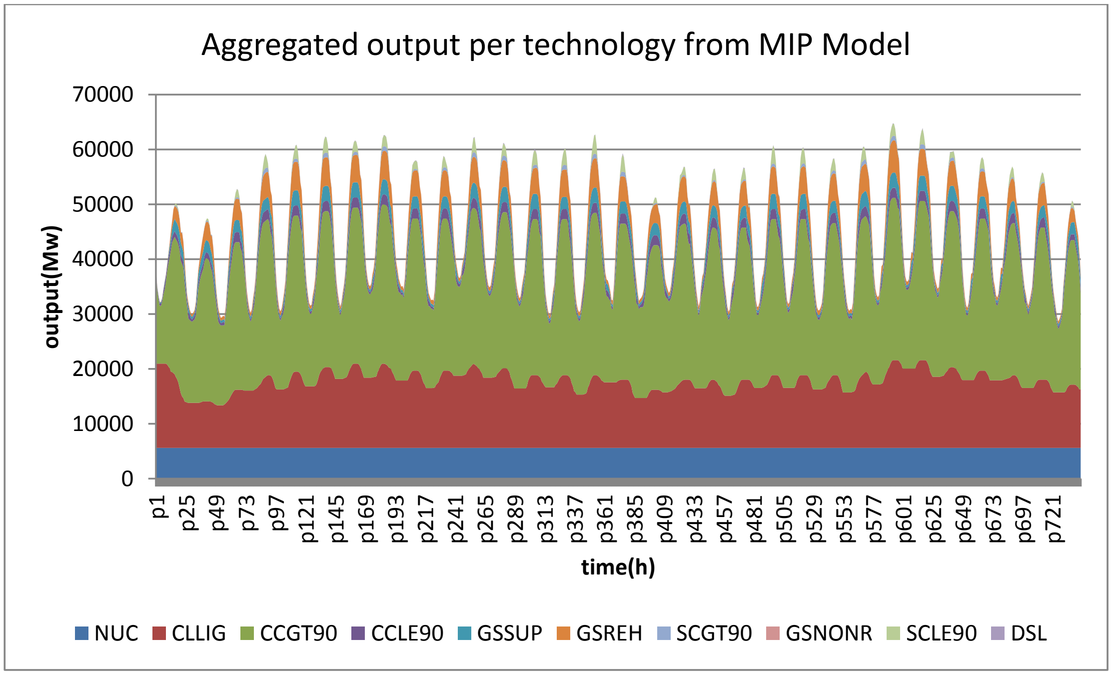

Figure 5.1: Aggregated output per technology from MIP Model

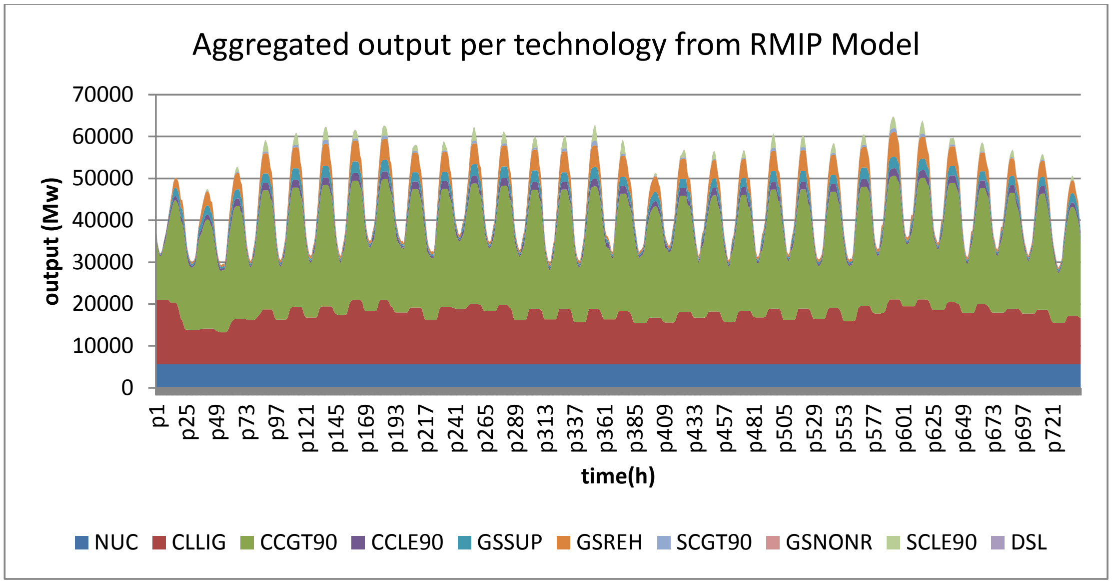

Figure 5.2: Aggregated output per technology from RMIP Model

It is observed that both models generally follow the merit principle order but not completely. Sometimes during the low demand hours, i.e., in the middle of the night or early morning, a cheap unit is backed down while an expensive one remains on. For instance, an operating schedule resulting from RMIP model during the period between p244 and p245 (August 11th Monday 03:00hrs to 04:00hrs) has been examined and results are shown in Table 5.1. It is seen that to handle a decrease in net load, a cheaper generating unit (CCGT90) has been shut down while a more expensive generator (e.g., GSSUP) still remains online. The situation could be explained by the presence of technical limits, e.g., minimum online/ offline time. More specifically, once an expensive unit starts up to meet the demand during peak hours, it still needs to remain on for a certain periods including the off-peak hours.

Table 5.1: Generation output of different technologies at period 245 from RMIP Model

	p244	**p245**
NUC	5615.00	5615.00
CLLIG	13260.30	13260.30
CCGT90	16281.34	16029.36
CCLE90	450.90	450.90
GSSUP	452.00	452.00
GSREH	713.05	690.55
SCGT90	21.60	21.60
GSNONR	0.00	0.00
SCLE90	0.00	0.00
DSL	0.00	0.00
Netload	36794.19	36519.71

Furthermore, as expected from UC models, the base load is supplied by cheap generating units, where nuclear units are operating at its maximum capacity and coal units varies slightly from peak to off-peak periods. The peak demand is delivered by activating the peak-expensive units, i.e., gas and diesel generating units. These units often ramp up/ start up during peak hours and ramp down/ shut down during off peak hours throughout the day. The marginal costs (denoted as EP_MIP and EP_RMIP) also follow the pattern of the peak-generating units' outputs, which is logical since they are the dual variable of the demand constraints,

5.1.2. Some observations on the model's marginal costs

As mentioned in chapter 2, marginal costs obtained from the model could provide an interesting insight regarding the nature of real prices and are the focus in this section. Examining the operating schedule of thermal units will be left for further study.

At the same time, one of the factors influencing the level of electricity demand and prices is the intensity of business and daily activities, which could be separated into weekdays and weekends. For better consistency and an in-depth analysis, only the weekday model will be examined for the rest of this work; and the weekend model will be left for the future study. There are a total of 4 weeks in August 2014 made up of 20 weekdays, which starts from Monday, August 4th 00.00 hrs (period 1) until Friday, August 29th 23.00 hrs (period 480).

In this section, some comments will be made on the obtained marginal costs and the real prices, and their relationship with the wind power, which hypothesis could be confirm in Chapter 6 with the econometric analysis.

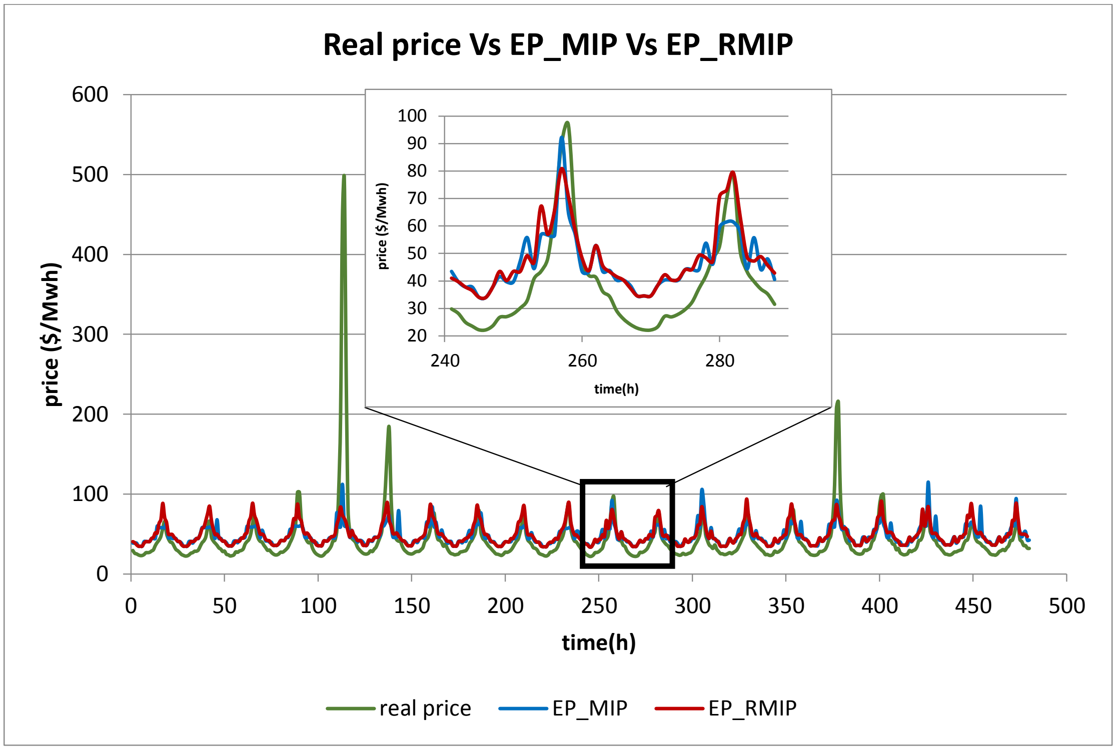

Figure 5.3: Real price vs. EP_MIP and EP_RMIP in the weekdays of August 2014.

As seen from Figure 5.3, model marginal costs follow the same pattern at the real prices with higher values during the peak-hours (in late afternoon) and lower values during the off-peak hours (at night and early morning). However they fail in capturing the price spikes at peak periods, for instance, on August 8th at 17.00 hrs (period 114) and August 25th at 16:00 hrs (period 377), when the real price goes up to above 495 and 200 $/ MWh respectively. According to [20], this event is explained due to the low system reserve capacity and under-generation caused by a quick load increase and low dispatchable capacity during these periods. It is also observed that during the off-peak periods, marginal costs are higher than the real prices. The lowest real price is 22.15 $/ MWh equal to the variable cost of a coal unit, while that of marginal costs is around 34 $/ MWh, which is the marginal cost of a CCGT unit. An examination regarding the prices and marginal costs during the off-peak hours will be conducted in the second part of this chapter, section 5.2.1 to explain this issue.

Another general observation from Figure 5.3 and Figure 5.4, is that for most of the time, EP_MIP and EP_RMIP are higher than the real prices. Additionally, EP_RMIP is slightly greater than EP_MIP (Figure 5.5), but during the peak-hours EP_MIP tends to resemble the real prices better (Figure 5.3). A quick analysis on the ratio of marginal costs and real prices, shown in Table 5.2, indicates that overall, EP_MIP values are closer to the real prices.

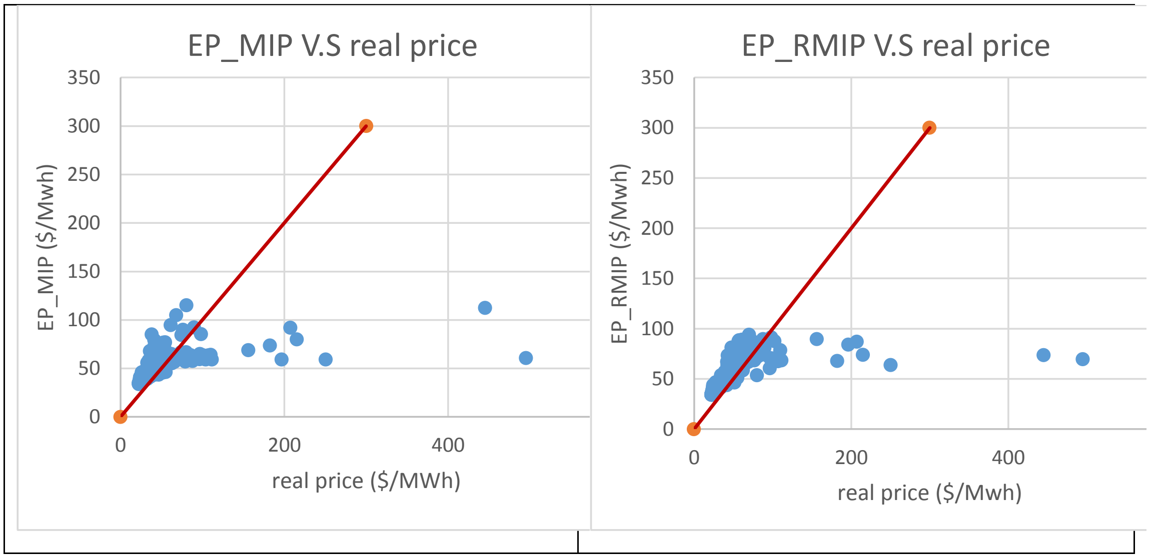

Figure 5.4: Real Price vs. estimated prices from UC model, August, 2014

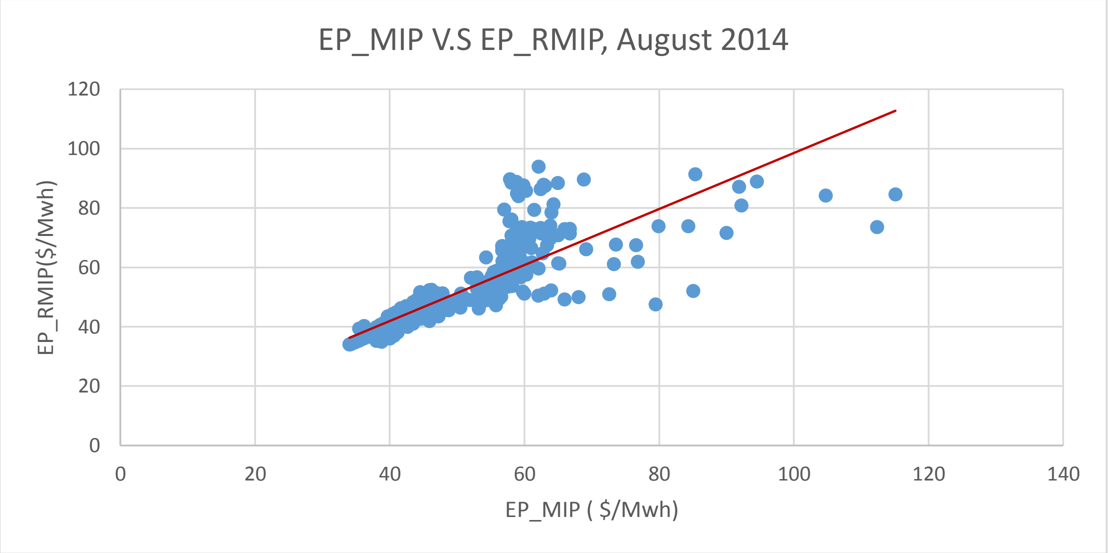

Figure 5.5: EP_MIP vs. EP_RMIP in August 2014

Table 5.2: Ratio of EP_RMIP / EP_MIP

	Ratio of EP_MIP/real price		Ratio of EP_RMIP/real price
Mean	1.31	**Mean**	1.33
Median	1.38	**Median**	1.38

Based on these comments, a pairwise student t test has been conducted to test if there is a significant difference of mean from the real prices, EP_MIP and EP_RMIP. The result of the test is summarized in Table 5.3, followed by some remarks.

Table 5.3: Results from paired t-test

Variable	Mean	Std. Dev	Result from paired t-test
Real price	42.28	37.12	
EP_MIP	48.01	11.78	
EP_RMIP	49.43	13.22	
(Real Price - EP_MIP)	-5.72	31.81	p-value = 0.0001, i.e., Mean significantly different
(Real Price - EP_RMIP)	-7.15	31.62	p-value = 0.000, i.e., Mean significantly different

The test result shows that real prices have a smaller mean but a much higher deviation compared to marginal costs obtained from UC models. This could also be observed graphically, Figure 5.3. Indeed, it is statistically significant different between the real price and EP_MIP (or EP_RMIP) as the *p*-value under the other hypothesis is less than 0.5. The difference could be explained by the presence of extreme prices located on the bottom right in Figure 5.4, e.g., 450 $/ MWh at period 114, 107 $/ Mwh at period 377.

In addition, the differences between real prices and EP_MIP and between real prices and EP_RMIP have a similar standard deviation. However, the former one has a smaller mean error. Thus, results from MIP model might resemble the real price better than that from RMIP model. This hypothesis will be examined later in chapter 6.

Next, the time series of marginal costs (served as a reference for prices) and wind output is illustrated in Figure 5.6 and Figure 5.7 . It can be observed that there is a negative correlation between marginal costs and wind output, i.e., higher wind output goes with lower costs and vice versa. During the peak hours in the late afternoon, there is less wind than off-peak hours at night and therefore the gap of obtained marginal costs between the peak and off-peak hours are even wider and clearer to observe.

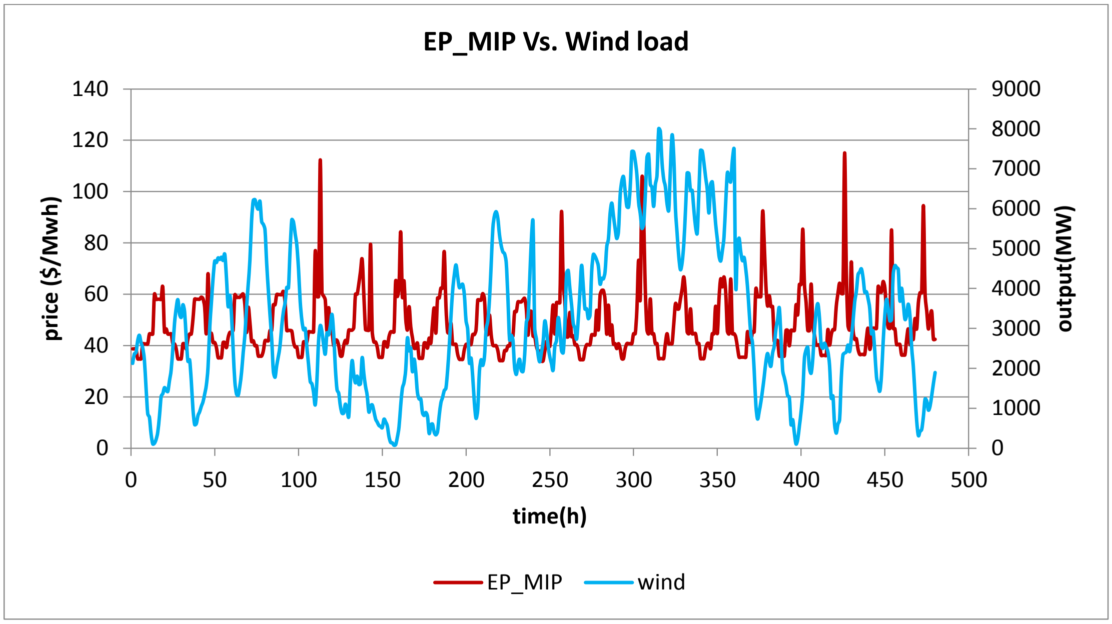

Figure 5.6:Wind output vs EP_MIP, weekdays, August 2014

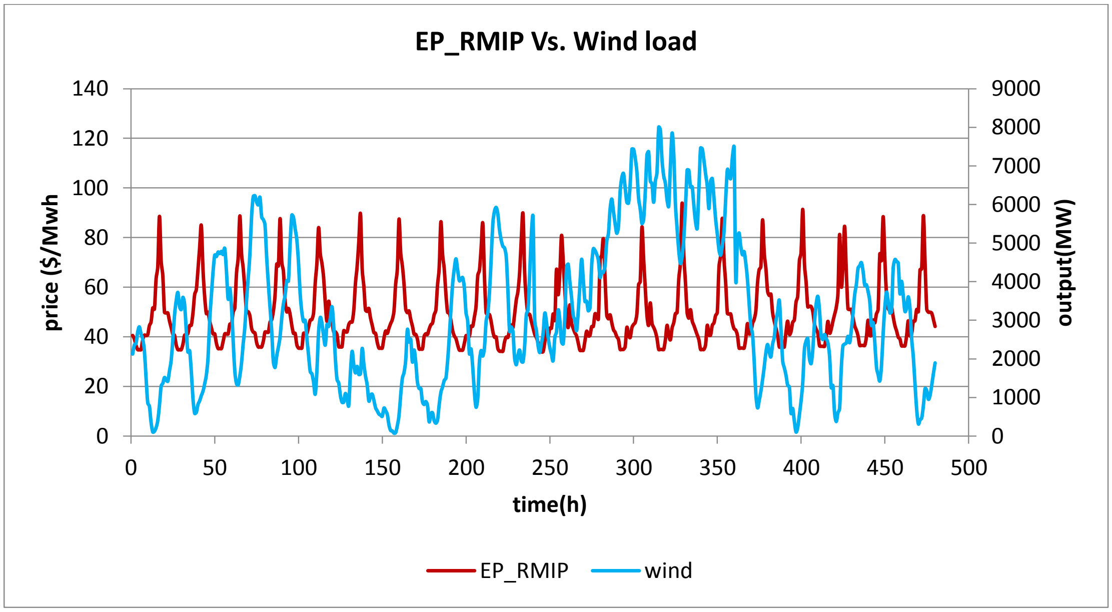

Figure 5.7: Wind output vs EP_RMIP, weekdays, August 2014

The relationships between the net load and real prices as well as obtained marginal costs are also depicted in Figure 5.8. In general, as expected, there seems to be a positive correlation of net load and the prices and marginal costs. However, this observation is less trivial in the case of real price vs. net load due to some outliers of real prices in the top right corner of the figure.

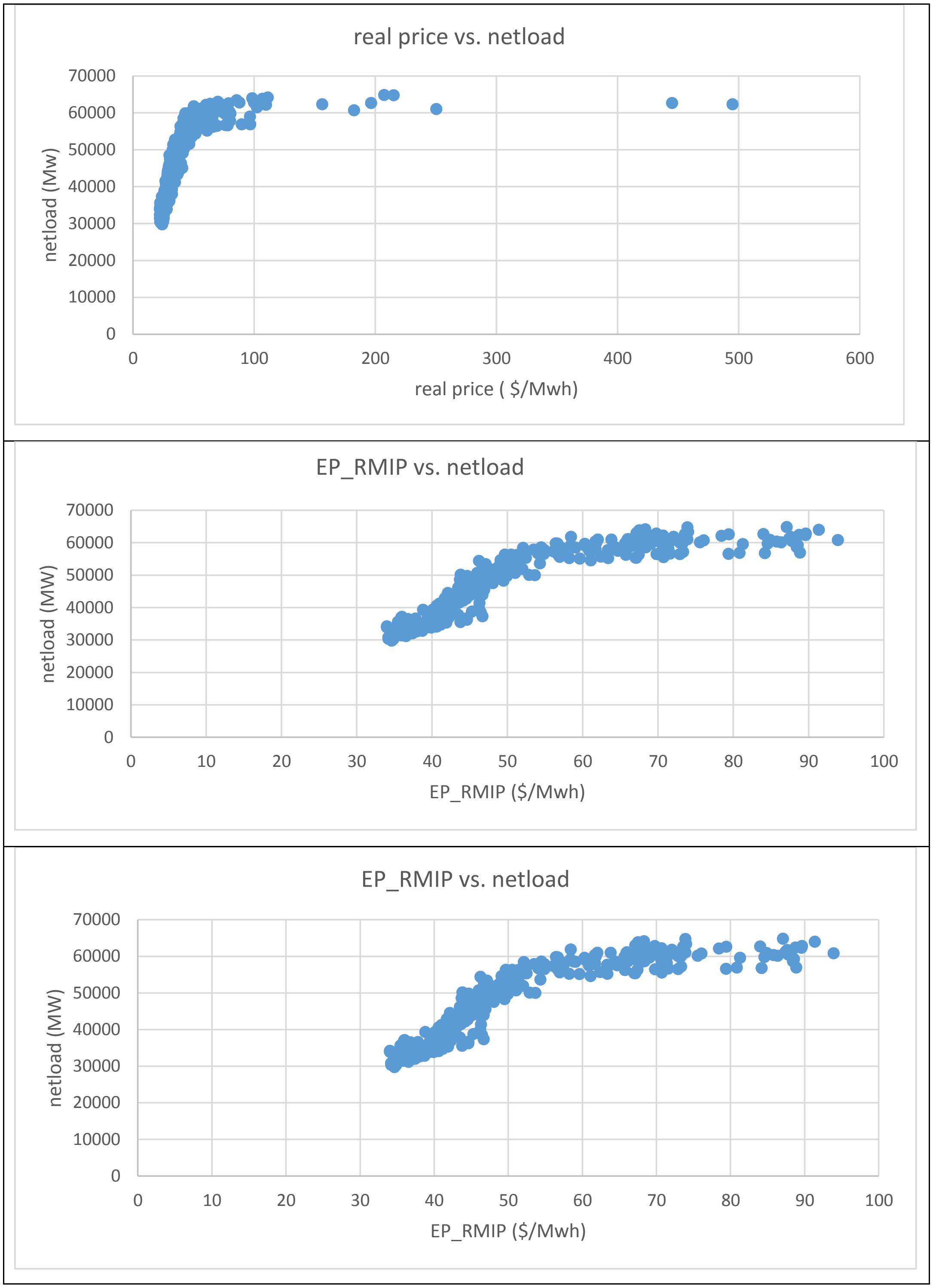

Figure 5.8: Real price, EP_MIP and EP_RMIP VS. Netload

Furthermore, there is an acknowledged trade-off between the model accuracy and the computational effort to be made between using MIP and RMIP models, , the summary of model statistics is shown in Table 5.4. On the one hand, MIP model took approximately 40 hours to run while RMIP model finished within 5 hours. On the other hand, as will be presented in Chapter 6, results from MIP model resemble the real prices much better than that from RMIP model. Other differences of two model's outputs will be discussed in more detailed on Chapter 6.

Table 5.4: UC model statistics

	UC MIP model	UC RMIP model
No. Of equations	5,277,945	5,277,945
No. Of single variables	3,525,073	3,525,073
No. Of discrete variables	1,096,168	1,096,168
CPU time	39 hours 25 minutes	4 hours 50 minutes

5.2. Model's output validation

In this section, there are two main validation tasks to carry out. The first one is to explain the concern raised in the section 5.1 about the difference between real prices and models' marginal costs during the low demand hours. And the second part is to validate the model output and the real output according to different types of technologies.

5.2.1. Analysis of the price at the off-peak hours

This section aims at explaining why during the off-peak hours, the model marginal cost is higher than the real price floor by performing a finite difference analysis. A specific hour has been chosen for the test, which is Thursday, 21st August at 4 AM (period 317), in which the case is run again using RMIP model with an increase of 250 MW in load to see the change in the economic dispatch, the result is shown in Table 5.5.

Table 5.5 : Summary of generation output

Type of units/ p317	Output from RMIP with initial load	Output from RMIP with increased load
NUC	5615.00	5615.00
CLLIG	10725.94	10725.94
CCGT90	11780.41	12030.41
CCLE90	450.90	450.90
GSSUP	452.00	452.00
GSREH	679.93	679.93
SCGT90	22.58	22.58
GSNONR	0.00	0.00
SCLE90	0.00	0.00
DSL	0.00	0.00
EP_RMIP	34.65	34.65

It is seen that the increased load is supplied by an increase in production from a CCGT90 unit, which has the marginal cost of around $ 34/ MWh. This is exactly the price floor obtained from the model, which indicates that the model built is running in a logical process. One possible reason for the difference between the price floors obtained from the model and reality is due to technical constraints. More specifically, some CCGT90 units have to keep producing due to its minimum on times, and due to the minimum off-time, they must stay offline so can immediately ramp up and produce during the peak-hours.

Another analysis to show that the price floor in the model could not could not decrease to $ 22/ MWh, which is the marginal cost of a coal plan. Figure 5.9 presents the coal generating units' outputs and their maximum capacities at hour 317. It is observed that there are 11/ 39 units that are offline and the rest are operating at its maximum capacity or its maximum ramp rate, thus it is not possible for them to ramp up anymore and CCGT plants have to do the work according to the merit order. One reason for this could be that in reality, the ramping limits of coal generating units are higher than the inputs used in the model. There might be other potential explanations that require further study, e.g., due to reserve requirements, presence of non-convexities in the cost function. However, due to the limited time and available data, especially private information belong to generating units, this topic will be left for future work.

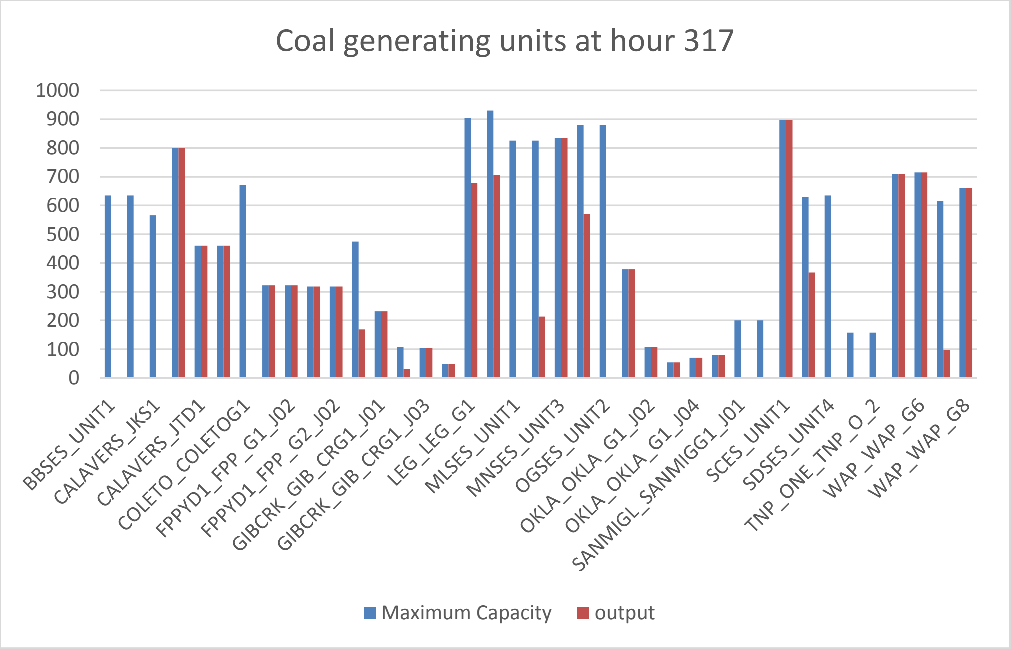

Figure 5.9: Coal generation at period 317

5.2.2. Validation with the real output

Without loss of generality, a specific day has been chosen to compare the output obtained from the model and in reality, which is Wednesday, from August 13th 00:00hrs to August 13th 23:00hrs (period 289 to period 312). The comparison will be done as a whole and in a detailed way according to different types of technologies, i.e., Combined Cycle, Gas Steam and Coal generating units. Most of the real input is taken from [50], except the energy by fuel type is taken from [51]. Numerical values can be found in Appendix C. It should be noted that throughout the validation, the output in reality is from the whole state of Texas, not only from the ERCOT System, due to difficulty in collecting the real data. However, ERCOT serves around 90% of the state's electric load[10], hence the model obtained output is supposed to resemble the real one closely with an expected gap of 10%.

First, regarding the total output, it is observed from Figure 5.10, the model output follows the real output thoroughly with only slight difference representing the 10% gap of the state's load served by units outside ERCOT System. Information regarding the composition of three main generating technologies, i.e., coal, nuclear and gas, is summarized in Table 5.6 and Figure 5.11.

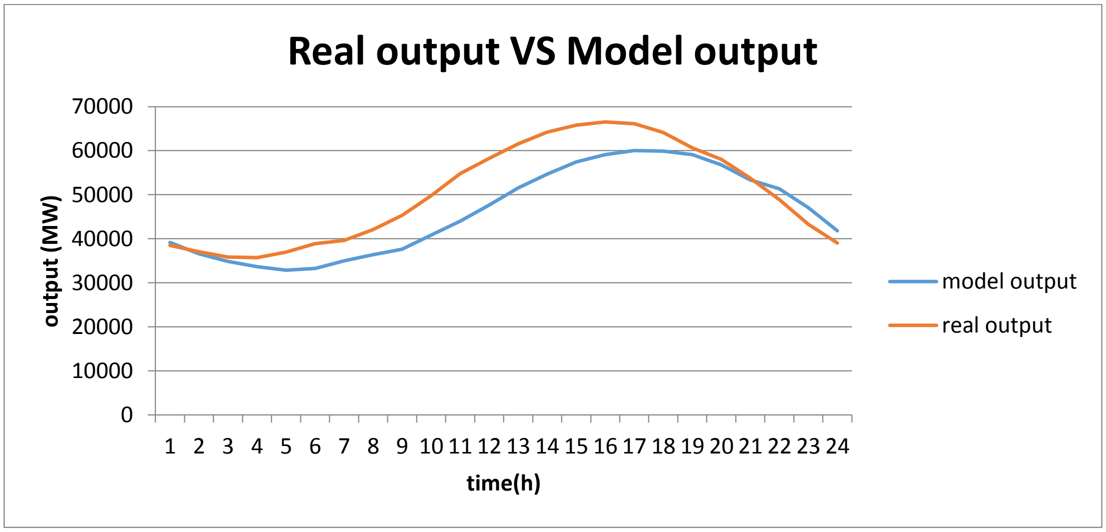

Figure 5.10: Real output vs. model output. Source: [50] and author's calculation.

Table 5.6. Energy by fuel type, percent. Source: [51]

	Energy by fuel type, percent	
Coal	**11.20 %**	12.21 %
Nuclear	**52.33 %**	61.83 %
Gas	**36.47 %**	**25.96 %**

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[10] http://www.ercot.com/about

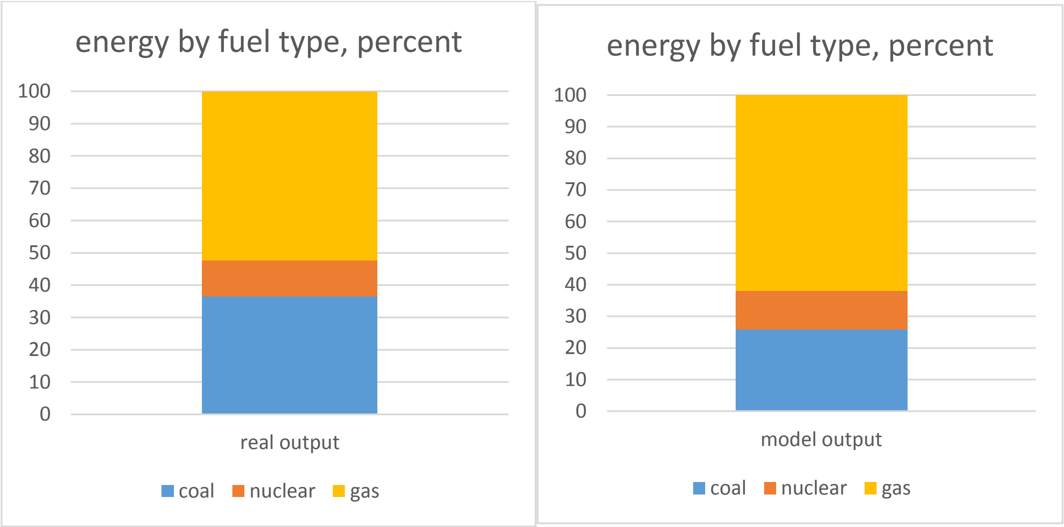

Figure 5.11: Energy by fuel type, real output (left) and model output (right). Source: [51] and author's calculation.

Next, the output of three type of generating units from the model and in reality will be compared, which is shown in Figure 5.12, Figure 5.13, and Figure 5.14 as below.

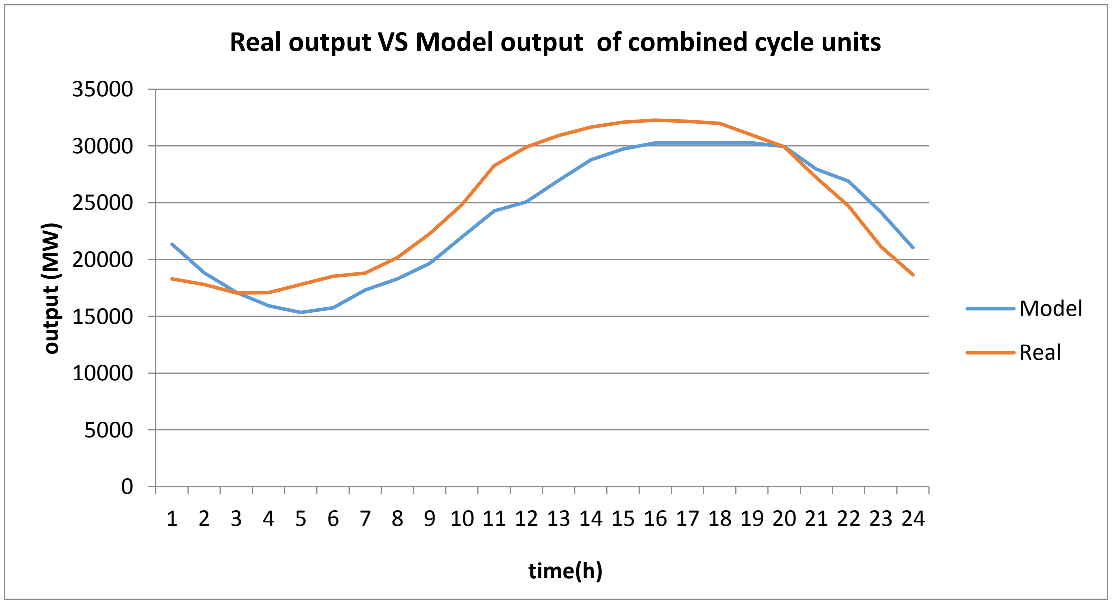

Figure 5.12: Real output vs. model output of combined cycle units. Source: [50] and author's calculation.

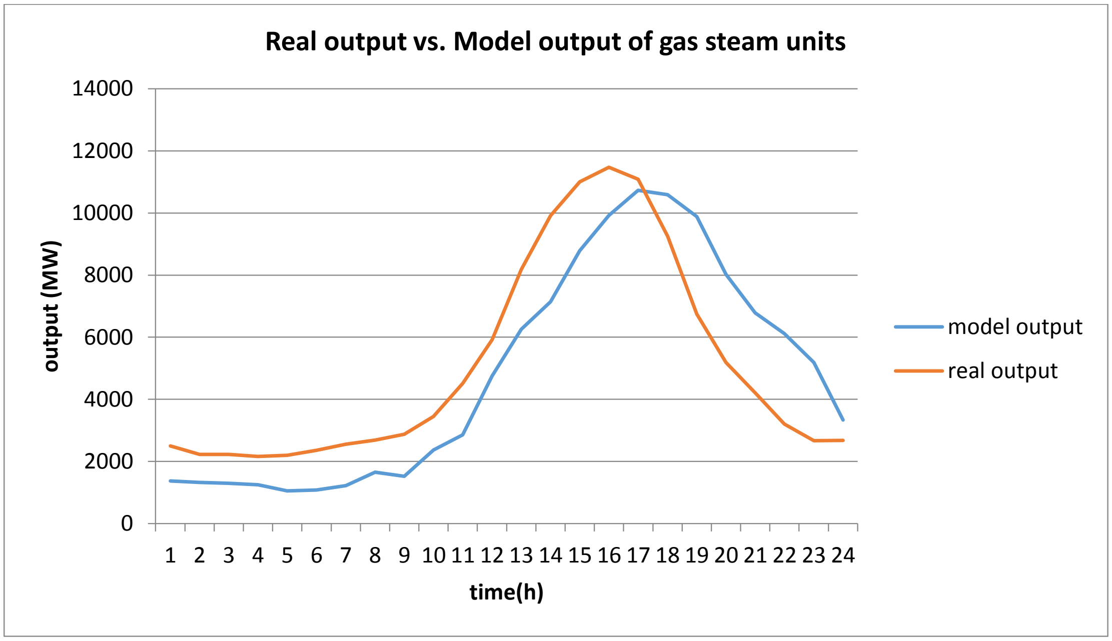

Figure 5.13: Real output vs. model output of gas steam units. Source: [50] and author's calculation.

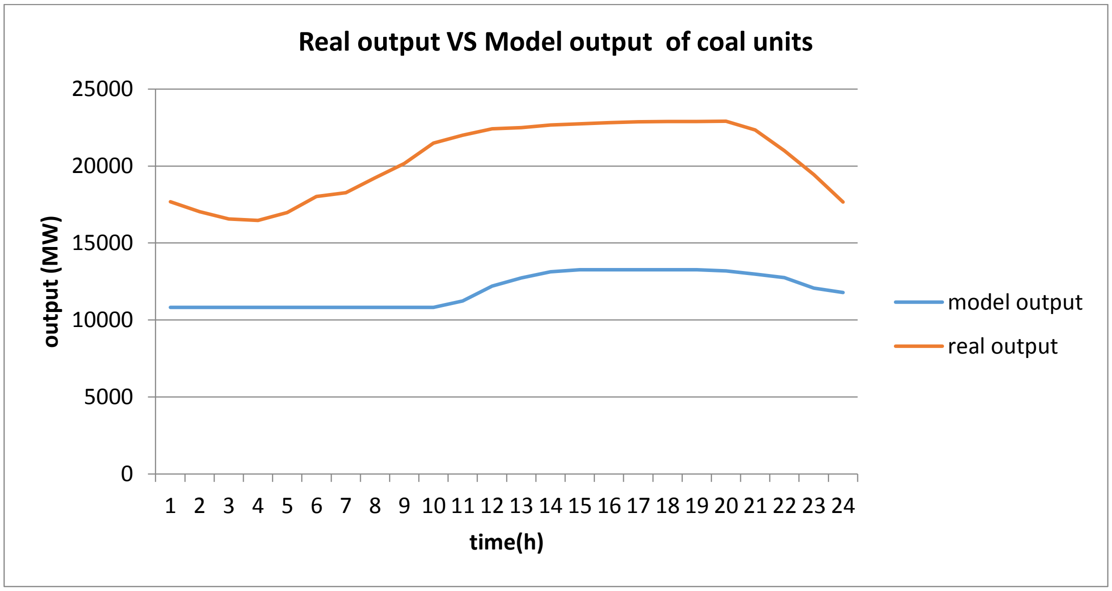

Figure 5.14: Real output vs. model output of coal units. Source: [50] and author's calculation.

As defined in Chapter 3, there are two types of combined cycle units in the model, which are Combined Cycle greater than 90 MW (CGT90) and Combined Cycle less than or equal to 90 MW (CCLE90). Furthermore, there are a group of three

Gas steam-generating units: Gas-Steam Non-reheat or boiler without air-preheater (GSNONR), Gas-Steam Reheat Boiler (GSREH) and Gas-Steam Supercritical Boiler (GSSUP). It is observed that the model and real output for combined cycle and gas generating units are pretty similar with a small difference and they both follow the same pattern with a flatter tail during the off-peak hours and a high peak during the high demand hours.

Regarding the output of coal generating units, even though the model evolves in the same pattern as the real data, there is a constant gap of around 7,000 MW. In the model, the total installed coal capacity is recorded at 18,822.2 MW, which is similar to the recorded coal summer capacity of ERCOT of 19,115 MW[11]. However, since data of total installed coal capacity in Texas is not available, thus the gap could be explained using the following estimation. First, the total coal generation in Texas in the month of August, 2014 is recorded at 14,614 thousand MWh[12] while that in ERCOT system is 12,140 GWh[13]. The value is recorded during a summer month, where most of the base-load generating units, e.g., coal units, are online and producing at its maximum capacity to serve high demand. Thus, it could be concluded that the installed coal capacity of ERCOT makes up about 83%, but not around 90% like other technologies, of total Texas's coal capacity, the latter is therefore estimated to be about 23,000 MW. As a result, the gap of 7,000 MW in Figure 5.14 is justified.

This validation section has shown that the generation output obtained from the model and in reality resemble each other closely. And the difference of approximately 10% in Figure 5.10, Figure 5.12, Figure 5.13, and 20% in Figure 5.14, are justified by the fact that the real outputs are of the whole Texas and the model only cover ERCOT system. Therefore, results obtained from the UC model are expected to resemble the real price closely and could offer a significant contribution

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[11] http://www.ercot.com/content/news/presentations/2013/CapacityDemandandReserveReport-May2013.pdf

[12] http://www.eia.gov/electricity/monthly/current_year/october2014.pdf

[13] www.**ercot**.com/ .../ **2014**/ .../ **CapacityDemandandReserveReport**-Dec**2014**.pdf

in finding the impact of wind generation on the prices, which are also the main purposes of this work.

6. RESULTS FROM THE ECONOMETRIC ANALYSIS AND SENSITIVITY ANALYSIS

The first part of this chapter presents the econometric analysis where several regression models are proposed and adjusted according to the available input data (real market prices, estimated marginal cost with the UC model, wind generation, and load). Among all these models, the one that performs the best in terms of accuracy is used to perform a sensitivity analysis where the influence of varying degrees of wind penetration on resulting market prices is assessed. Ultimately, the first and second sub-questions mentioned in chapter 1 would be answered. These are:

(1) What is the connection between the theoretical marginal cost and the observed electricity price?

(2) How does changing wind load profiles influence electricity prices estimated in this study?

Sub-question 3 regarding a better way of predicting DAM electricity prices and the main research question will be discussed in the next chapter as conclusions drawn from the whole study.

6.1. Econometric regression analysis

6.1.1. Experimental Design

The econometric regression analysis is performed to find the relationship between the model's marginal costs and real prices. This section covers the detailed analysis procedure.

As presented in section 3.2, there are three categories of models used in this work. The first type is the pure time series approach, the second type is based on fundamental engineering model (UC) and the last one is a hybrid model combining a fundamental model with an econometric analysis. More specifically, the UC model has been run using two approaches: MIP and RMIP. And in hybrid models, there are two types of mark-ups , i.e., mark-up M and mark-up L. Thus, a total of seven models have been examined in this study, as shown by Figure 6.1.

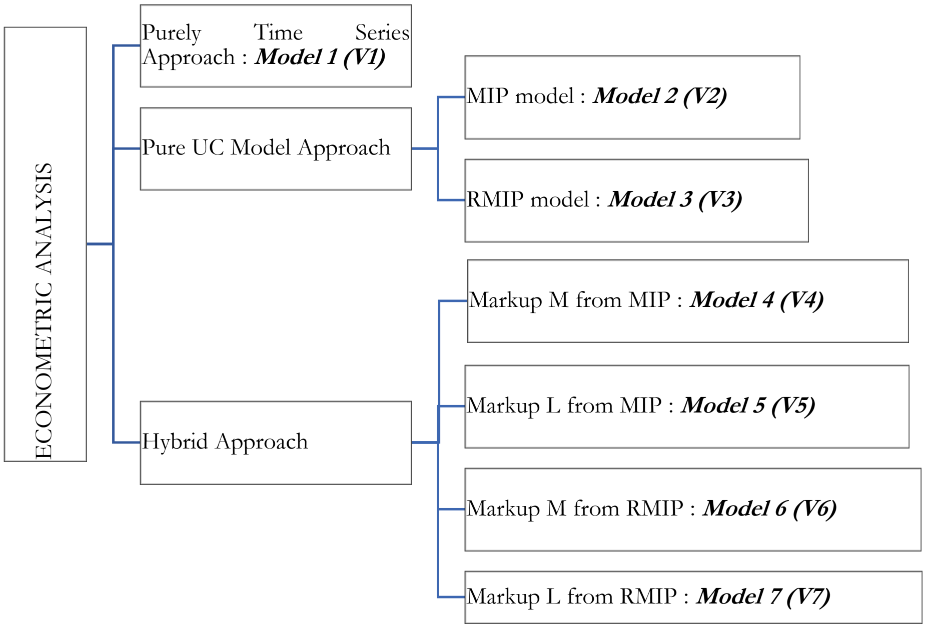

Figure 6.1: Seven Models in Econometric Analysis

Detailed formulation of proposed seven models are described in chapter 3 (equation (3.46) to (3.52b)) and represented below in Table 6.1.

Table 6.1: Model structure

Model 1 (V1): $Estimated\ P(t) = \alpha + \beta_1 * P(t-24) + \beta_2 * NL(t) + \beta_3 * [NL(t)]^2$	(3.46)
Model 2 (V2): $Estimated\ P(t)$ $= \alpha + \beta_1 * EP\_MIP(t) + \beta_2 * P(t-24) + \beta_3 * NL(t) + \beta_4$ $* [NL(t)]^2$	(3.47)
Model 3 (V3):	(3.48)

$Estimated\ P(t) = \alpha + \beta_1 \ast EP\_RMIP(t) + \beta_2 \ast P(t-24) + \beta_3 \ast NL(t) + \beta_4 \ast [NL(t)]^2$	
Model 4 (V4): $Estimated\ M(t) = \alpha + \beta_1 \ast M(t-24) + \beta_2 \ast NL(t) + \beta_3 \ast [NL(t)]^2$ $Estimated\ P(t) = 10^\wedge(\log(EP\_MIP) + Estimated\ M(\mathrm{t})$	 (3.49) (3.50a)
Model 5 (V5): $Estimated\ L(t) = \alpha + \beta_1 \ast L(t-24) + \beta_2 \ast NL(t) + \beta_3 \ast [NL(t)]^2$ $Estimated\ P(t) = EP\_MIP/(1 - Estimated\ \ L(t))$	 (3.51) (3.52a)
Model 6 (V6): $Estimated\ M(t) = \alpha + \beta_1 \ast M(t-24) + \beta_2 \ast NL(t) + \beta_3 \ast [NL(t)]^2$ $Estimated\ P(t) = 10^\wedge(\log(EP\_RMIP) + Estimated\ M(\mathrm{t})$	 (3.49) (3.50b)
Model 7 (V7): $Estimated\ L(t) = \alpha + \beta_1 \ast L(t-24) + \beta_2 \ast NL(t) + \beta_3 \ast [NL(t)]^2$ $Estimated\ P(t) = EP\_RMIP/(1 - Estimated\ \ L(t))$	 (3.51) (3.52b)

In addition, as mentioned in chapter 5, the focus of this work is on building a weekday model, which is different from the weekend one due to the different intensity of business and daily activities. There are several models proposed, however only the one with best model fit will be chosen to conduct a sensitivity analysis later in the chapter. The 4 weeks in August 2014 are divided into 2 two-week sets for deriving the models and for testing the models. Specifically, the first set is used to derive the regression model and the second one is used to validate the model obtained as an out-of-sample validation.

Furthermore, to achieve a robust solution, the chosen model should also consistently outperform the others in different time frames. Due to limited computational capability at the moment, the model could not run for more than one month. However, by swapping the order of weeks during the month, seven different cases are created as shown in Figure 6.2, and the best fit model overall could be identified. Table 6.1

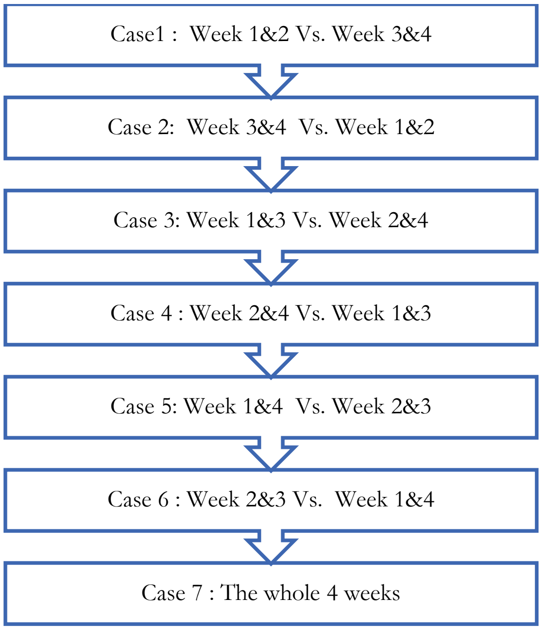

Figure 6.2 : Cases with different sets of Weeks of Study

To sum up, the econometric analysis has been conducted for all 7 models under 7 different cases, see Figure 6.3, thus a total of 49 econometric regression models are obtained.

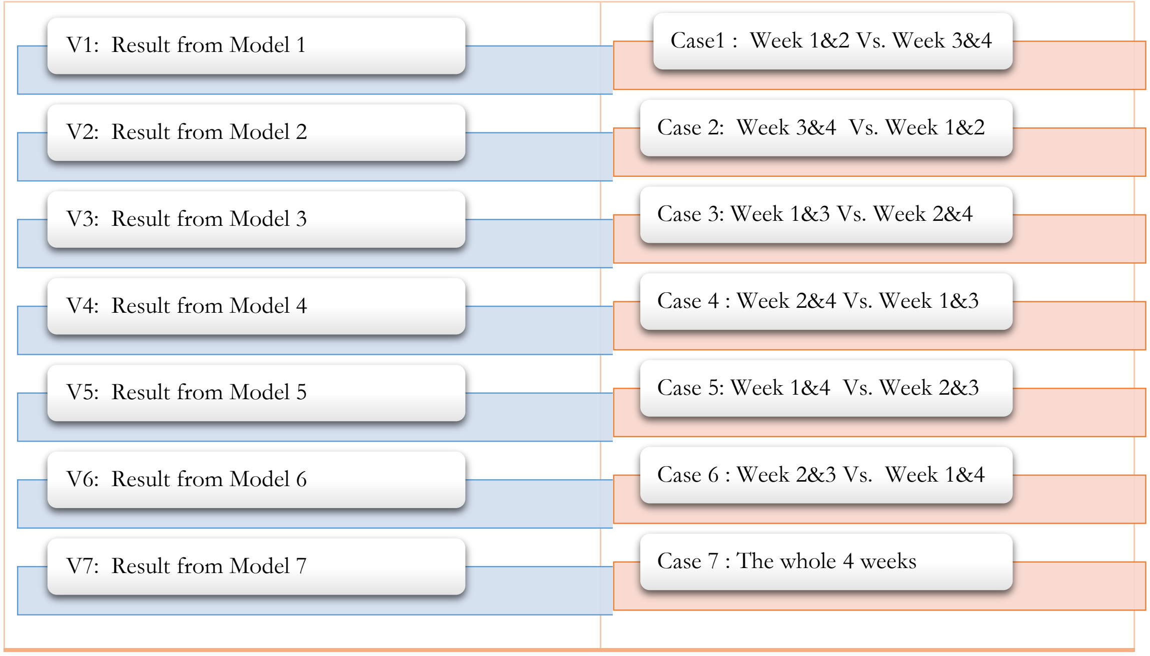

Figure 6.3: Models and cases studied in the econometric analysis

It should be noted that regression models in this work requires information of the real value of dependent variable at time (t-24). Thus, in the data set containing the first week, there will be only 216 values (9 weekdays) instead of 240 (10 weekdays) like in others. Regarding the real data of dependent variables at time (t-24) for every hour *t* on Monday, Figure 6.4 shows that real prices of previous Friday are better than that of previous Sunday in resembling prices of Monday. It is particularly obvious during the second Monday of the month. Thus, unlike other days during the week, the value of dependent variable at time (t-24) of every hours on Monday is taken from the value at the same hour on previous Friday.

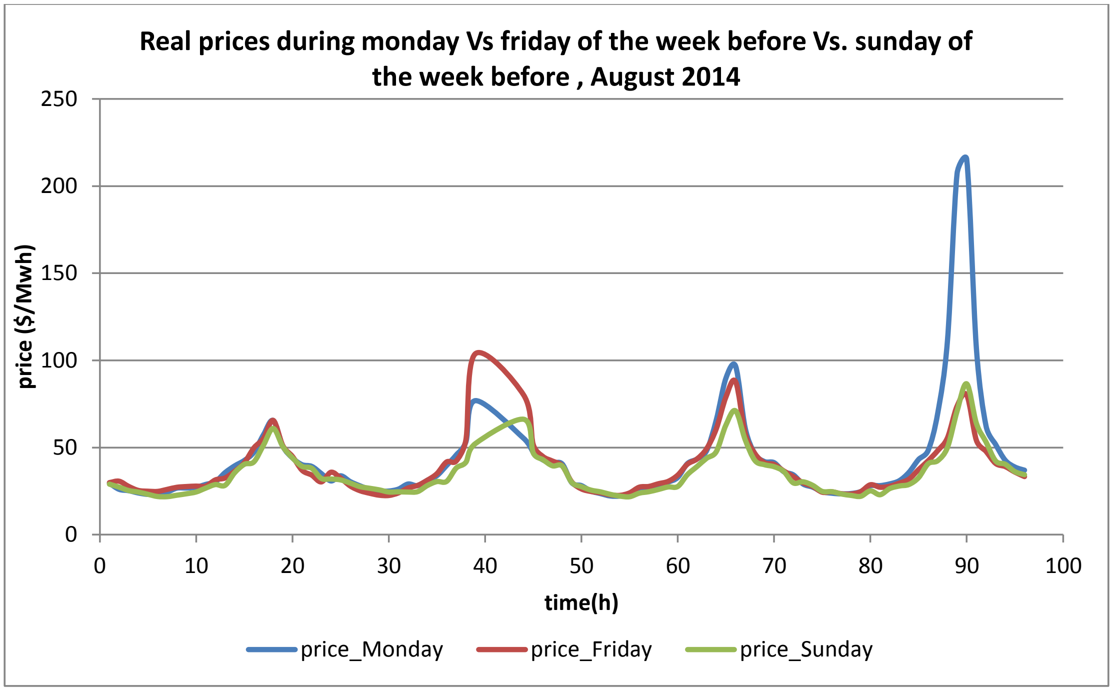

Figure 6.4: Real prices during Monday, Friday of the week before and Sunday of the week before , August 2014

6.1.2. Results from econometric analysis

Full outcomes of the econometric analysis could be found in Appendix D. In this section, specific results are presented to answer the first sub-question: *What is the connection between the theoretical marginal cost and the observed electricity price?*

Connection between theoretical marginal costs (EP_MIP and EP_RMIP) and the observed electricity prices are presented by coefficient β_1 in the following two equations (3.47) and (3.48).

Model 2 (V2):

$$\text{Estimated } P(t) = \alpha + \beta_1 * EP\_MIP(t) + \beta_2 * P(t-24) + \beta_3 * NL(t) + \beta_4 * [NL(t)]^2 \qquad (3.47)$$

Model 3 (V3):

$$\begin{aligned} &\text{Estimated } P(t) \\ &\quad = \alpha + \beta_1 * EP\_RMIP(t) + \beta_2 * P(t-24) + \beta_3 * NL(t) + \beta_4 * [NL(t)]^2 \end{aligned} \qquad (3.48)$$

Most notably, in all 7 cases, the coefficients β_1 of model V2 and V3 are statistically significant with $p < 0.05$. In other words, the null hypothesis that the coefficient is equal to zero can be rejected, thus the marginal costs are likely to be a meaningful addition to the model.

Value of β_1 and the constant terms in the regression models V2 and V3 are summarized in Table 6.2 below.

Table 6.2: Coefficients of EP_MIP and EP_RMIP in regression models

		β_1	**Constant Term**
Case 1 : Week 1&2 Vs. Week 3&4	Model V2	2.24	153.99
	Model V3	-0.03	261.53
Case 2 : Week 3&4 Week Vs. 1&2	Model V2	0.47	160.86
	Model V3	0.43	151.83
Case 3 : Week 1&3 Week Vs. 2&4	Model V2	0.16	144.51
	Model V3	-2.75	344.84
Case 4 : Week 2&4 Week Vs. 1&3	Model V2	0.44	146.04
	Model V3	0.3	141.73
Case 5 : Week 1&4 Week Vs. 2&3	Model V2	1.3	237.68
	Model V3	0.06	276.25
Case 6 : Week 2&3 Week Vs. 1&4	Model V2	0.28	49.19
	Model V3	0.55	6.8
Case 7: Whole weekdays	Model V2	0.92	178.87
	Model V3	0.21	199.18

Overall, most of the time, the model's marginal costs have positive correlations with the real prices, except in model V3 (case 1) and model V3 (case 3) . However, in these two cases the constant term in the regression models are also of the highest, i.e., 261.53 and 344.84.

Theoretically, if the market is perfectly competitive, coefficient β_1 would be expected to be equal to 1. However, the value obtained from the study shows a clear deviation from 1, and the closest to 1 that β_1 could achieve are 1.3 of model V2 in case 5 and 0.92 of model V3 in case 7. The total absolute variation of β_1 from 1 in total 7 cases are 4.27 and 8.23 for model V2 and V3 respectively. Thus, if the study is done under the assumption of a perfectly competitive market, marginal cost obtained from MIP approach (V2) performs better than marginal cost obtained from RMIP approach (V3).

Regarding the observed deviation, there might be several potential explanations. First, it might be due to the presence of other independent variables, i.e., net load and net load squared in the regression model, which cause the coefficients of EP_MIP and EP_RMIP to be distorted from the expected value. To check this, one possible test is to ignore the existence of other explanatory variables. even though as identified in the literature, they have significant impact to prices. Another regression model for whole weekdays (case 7) has been obtained, in which EP_MIP/ EP_RMIP is the only independent variable, the model obtained is shown in Table 6.3. The new coefficient of EP_MIP deviates further than in the initial model, but that of EP_RMIP is closer to 1, with the new coefficient of 1.59 compared to 0.21 in the original case. It would be a good exercise to examine the rest 6 cases to observe the changes of the coefficients of EP_MIP and EP_RMIP to confirm the hypothesis, which is left for further study due to limited time.

Table 6.3: Regression model for Case 7 without net load and net load squared, V2 and V3

	Regression Model
Case 7-V2	Estimated Price (t) = 1.82 * EP_MIP(t) – 44.9
Case 7-V3	Estimated Price (t) = 1.59 * EP_MIP(t) – 36.2

Secondly, as observed from Figure 6.5, there are six extreme prices (outliers) close to and over 200 $/ MWh. These outliers are at period 112, 113, 114, 115, 377 and 378. Due to their presence, the coefficients of independent variables have to be adjusted to derive the best fit model to real prices with the smallest sum of squared errors. To check this hypothesis, regressions are conducted again for case 7 with only

EP_MIP/ EP_RMIP as explanatory variable and outliers removed. The regression models are presented in Table 6.4, showing the coefficients are much closer to 1 than the previous models.

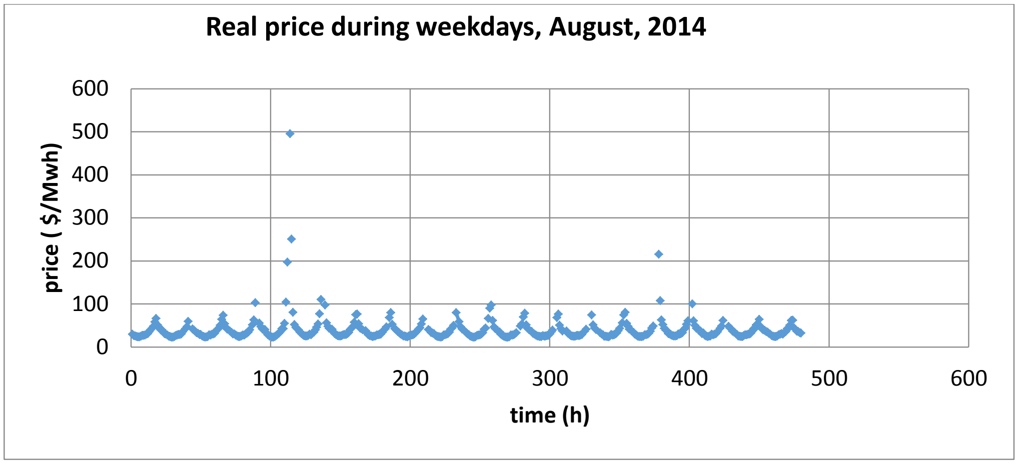

Figure 6.5: Real price during weekdays of August 2014

Table 6.4: Regression model for Case 7 without outliers, V2 and V3

	Regression Model
Case 7-V2	Estimated Price (t) = 1.22 * EP_MIP(t) – 19.07
Case 7-V3	Estimated Price (t) = 1.19 * EP_MIP(t) – 19.45

Furthermore, in an imperfect competitive market, the real prices could be higher than theoretical marginal cost, then a coefficient β_1 of 1 would not be expected. Thus, the observed deviation could be an indication of market power, although more research is required to confirm this. Last but not least, even though costs used in UC model have been calculated with best effort to represent the reality, there might be some significant difference from the real ones used in the ERCOT system.

It is also interesting to note that the real value of dependent variable at time (t-24) has a significant positive correlation with the estimated value at time t, which is coherent with their expected influence since the prices have a circular pattern of being lower during night time and early morning and higher during the day time.

6.2. Comparison of different approaches

There are a total of 7 cases made up by different combinations of weeks in August, 2014. In each case, the first data set is used to derive the regression model and the second set is used as an out-of-sample data test. After predicted prices in each case using the models are obtained, another regression analysis is conducted, in which there predicted prices are the only explanatory variable and the real prices are the dependent variable. The coefficients of these estimated prices in the analysis are summarized in Table 6.5. It is observed that the estimated prices resemble the real one closely. The average absolute deviation from 1 of these coefficients is 0.16 in case of in-sample validation, and 0.56 for out-of-sample set. Further statistical tests to compare different models will be described in detail in this section.

Table 6.5: Coefficient of estimated prices in regression models

Case	Model	first data set	second data set	Case	Model	first data set	second data set
case 1	V1	1	0.79	case 5	V1	1.01	0.5
	V2	0.99	0.54		V2	1.01	0.54
	V3	1.01	0.79		V3	0.99	0.49
	V4	1.29	0.85		V4	1.31	0.66
	V5	1.6	0.93		V5	1.54	0.92
	V6	1.17	0.95		V6	1.25	0.66
	V7	1.39	1		V7	1.46	0.84
case 2	V1	0.99	1.25	case 6	V1	1	1.86
	V2	0.99	1.41		V2	1	1.88
	V3	0.99	1.3		V3	1	1.74
	V4	1	1.68		V4	0.98	1.75
	V5	1.06	1.89		V5	1.05	1.84
	V6	1.06	1.42		V6	1	1.88
	V7	1.1	1.56		V7	1.08	
case 3	V1	1	0.15	case 7	V1	1.01	
	V2	1	0.15		V2	1.01	
	V3	1	0.11		V3	0.99	
	V4	1.45	0.4		V4	1.31	
	V5	1.76	0.8		V5	1.54	
	V6	1.54	0.18		V6	1.25	
	V7	1.79	0.45		V7	1.46	
case 4	V1	1	1.87				
	V2	1	1.88				
	V3	0.99	1.79				
	V4	1.04	1.97				
	V5	1.14	2.08				

	V6	1.04	1.84				
	V7	1.14	1.98				

To assess the predictive capability of different proposed models, there are three main statistical measures identified in literature: R^2, mean and standard deviation of errors and mean and standard deviation of absolute errors [7][15][52]. These main measures are compared for the 7 cases. Numerical results are presented in each of the following sections. Additionally, it should be noted that in August 2014 the real prices are the most volatile in the first week, followed by the last week, Figure 6.5, due to some extreme prices above 200 $/ MWh, e.g., 495 $/ MWh at period 114 (1st week), 215 $/ MWh at period 378 (4th week). For the rest of the month, prices evolve in a similar circular pattern of being lower during the off-peak hours and higher during the peak demand hours with a little variation at the same hour on different days. Thus, it could be expected that the difference between model estimated and real prices are biggest in the set containing week 1, followed by week 4. Details verifying this hypothesis are mentioned briefly in each of the following subsections.

6.2.1. Model R^2

R^2 is a useful statistical criteria in assessing different models since it measures how well the regression line approximates the real data points. The higher the R^2value, the better the model in fitting the real data. In each of the 7 cases above, the obtained models are validated with both the first data set (in-sample data) and the second data set (out-of-sample data). The Table 6.6 summarizes the obtained R^2 from in-sample and out-of-sample data for each model in every case. The model with highest R^2 in each case is highlighted.

In general and as expected, R^2 value is much higher in the set not including week 1 or/ and week 4 (either in-sample or out-sample set) . For instance, in case 1, the highest value of R^2 of in data set consisting of week 1 and 2 is 48%, while in the set of 3 and 4, this value increases to 71%. More specifically, in case 5 and case 6, where week 1 and 4 belong to a set, the R^2 are only 45% and 47% respectively, compared to 89% and 94% for the set of week 2 and 3.

In terms of R^2, it is observed that model V5 performs the best, having the highest value of R^2 in 8/ 13 times (in 7 cases and including both in-sample and out-of-sample sets), followed by model 4 with 4/ 13 times. Another way to access the performance of different models in terms of R^2 is by ranking. Specifically, in every case, the model with highest in-sample highest R^2 receives a score of 7, and the one with lowest R^2 gets a score of 1 and so on. If there is a tie, each model will receive the mean value. The same procedure is applied to out-of-sample R^2. The final score of each model is the sum of the two and summarized in the last column of Table 6.6 and Table 6.7, Table 6.8 and Table 6.9.

Table 6.6: Summary of obtained R2 from econometric models

Case	Model	In sample R^2	Rank of in sample R^2	Out-of-sample R^2	Rank of out-of-sample R^2
Case 1 1&2 Vs. 3&4	V1	0.35	3	0.68	5
	V2	0.42	5	0.62	1
	V3	0.35	3	0.67	4
	V4	0.45	6	0.71	7
	V5	0.48	7	0.69	6
	V6	0.34	1	0.66	3
	V7	0.35	3	0.64	2
	MAX	**0.48**		**0.71**	
Case 2 3&4 Vs. 1&2	V1	0.68	2	0.35	2
	V2	0.7	5	0.38	5
	V3	0.69	3.5	0.35	2
	V4	0.71	6.5	0.46	6
	V5	0.71	6.5	0.48	7
	V6	0.69	3.5	0.35	2
	V7	0.67	1	0.36	4
	MAX	**0.71**		**0.48**	
Case 3 1&3 Vs. 2&4	V1	0.52	3.5	0.51	3.5
	V2	0.52	3.5	0.51	3.5
	V3	0.59	7	0.47	1
	V4	0.58	6	0.65	6
	V5	0.54	5	0.74	7
	V6	0.51	2	0.48	2
	V7	0.46	1	0.6	5
	MAX	**0.59**		**0.74**	
Case 4 2&4 Vs. 1&3	V1	0.74	4.5	0.37	4
	V2	0.75	6.5	0.4	5
	V3	0.74	4.5	0.36	2.5
	V4	0.75	6.5	0.47	6.5
	V5	0.72	2.5	0.47	6.5
	V6	0.72	2.5	0.35	1
	V7	0.69	1	0.36	2.5
	MAX	**0.75**		**0.47**	
Case 5	**V1**	**0.37**	**3.5**	**0.86**	**2.5**

1&4 Vs. 2&3	V2	0.4	5	0.86	2.5
	V3	0.37	3.5	0.87	4
	V4	0.47	6.5	0.88	5.5
	V5	0.47	6.5	0.85	1
	V6	0.36	1.5	0.89	7
	V7	0.36	1.5	0.88	5.5
	MAX	**0.47**		**0.89**	
Case 6 2&3 Vs. 1&4	V1	0.92	5	0.34	3.5
	V2	0.93	6	0.37	5
	V3	0.94	7	0.33	1.5
	V4	0.86	2	0.44	6
	V5	0.8	1	0.45	7
	V6	0.91	4	0.33	1.5
	V7	0.87	3	0.34	3.5
	MAX	0.94		0.45	
Case 7 Whole weekdays	V1	0.41	3.5		
	V2	0.44	5		
	V3	0.41	3.5		
	V4	0.48	6		
	V5	0.59	7		
	V6	0.4	1.5		
	MAX	0.59			

Table 6.7: Total ranking of 7 model in terms of R^2

Model/Case	**Case 1**	**Case 2**	**Case 3**	**Case 4**	**Case 5**	**Case 6**	**Case 7**	**SUM**
	1&2 Vs. 3&4	**3&4 Vs. 1&2**	**1&3 Vs. 2&4**	**2&4 Vs. 1&3**	**1&4 Vs. 2&3**	**2&3 Vs. 1&4**	**Whole weekdays**	
V1	8	4	7	8.5	6	8.5	3.5	45.5
V2	6	10	7	11.5	7.5	11	5	58
V3	7	5.5	8	7	7.5	8.5	3.5	47
V4	13	12.5	12	13	12	8	6	**76.5**
V5	13	13.5	12	9	7.5	8	7	**70**
V6	4	5.5	4	3.5	8.5	5.5	1.5	32.5
V7	5	5	6	3.5	7	6.5	1.5	34.5

Table 6.8: Ranking of 7 models in terms of in-sample R^2

Model/Case	**Case 1**	**Case 2**	**Case 3**	**Case 4**	**Case 5**	**Case 6**	**Case 7**	**SUM**
	1&2 Vs. 3&4	**3&4 Vs. 1&2**	**1&3 Vs. 2&4**	**2&4 Vs. 1&3**	**1&4 Vs. 2&3**	**2&3 Vs. 1&4**	**Whole weekdays**	
V1	3	2	3.5	4.5	3.5	5	3.5	25
V2	5	5	3.5	6.5	5	6	5	36
V3	3	3.5	7	4.5	3.5	7	3.5	32
V4	6	6.5	6	6.5	6.5	2	6	**39.5**
V5	7	6.5	5	2.5	6.5	1	7	**35.5**

V6	1	3.5	2	2.5	1.5	4	1.5	16
V7	3	1	1	1	1.5	3	1.5	12

Table 6.9: Ranking of 7 models in terms of out-sample R^2

Model/Case	**Case 1**	**Case 2**	**Case 3**	**Case 4**	**Case 5**	**Case 6**	**Case 7**	**SUM**
	1&2 Vs. 3&4	**3&4 Vs. 1&2**	**1&3 Vs. 2&4**	**2&4 Vs. 1&3**	**1&4 Vs. 2&3**	**2&3 Vs. 1&4**	**Whole weekdays**	
V1	5	2	3.5	4	2.5	3.5	0	20.5
V2	1	5	3.5	5	2.5	5	0	22
V3	4	2	1	2.5	4	1.5	0	15
V4	7	6	6	6.5	5.5	6	0	**37**
V5	6	7	7	6.5	1	7	0	**34.5**
V6	3	2	2	1	7	1.5	0	16.5
V7	2	4	5	2.5	5.5	3.5	0	22.5

From the table of results above, the hybrid models resulting from MIP approach (V4 and V5) apparently outperform the pure time series and UC models (V1 to V3), both in terms of overall ranking shown in Table 6.7 and component-wise, i.e., ranking in terms of in-sample and out-of-sample R^2 presented in Table 6.8 and Table 6.9. Even though V5 is the best model with highest R^2 value occurring more frequently than V4, in terms of the final ranking with the chosen rational procedure explained above, V4 achieves slightly better rank with 9.3%, 11.3% and 7.2% higher in the overall, in-sample and out-of-sample value respectively than V5. As a conclusion, based on R^2 criteria, either V4 or V5 could be chosen as the best models for further analysis.

6.2.2. Mean and standard deviation of daily errors

As identified in literature and regularly used as a standard measure in accessing performance of different models, mean and standard deviation of errors over a period of time, i.e., weekly, monthly, are also used as criteria to compare the seven models. There are in total 20 weekdays in August 2014, which was divided into 2 sets of 10 weekdays (240 hours). The predicted value however requires the real data of independent variables at time (t-24), hence in the set that includes week 1, there are only 9 days or 216 hours. Hence the final value used is the mean and standard deviation (DV) of 10 days/ 9 days errors, depending on whether or not the data set including the first week. First, the average prediction error in percentage of 24h is computed for each day using equation (6.1). Then the average and standard deviation of these ten/ nine daily mean errors are computed and used as the assessment criteria.

Table 6.10 and Table 6.11 summarize the obtained value and highlights the smallest mean and standard deviation errors for each case, more details could be found in Appendix E.

$$Prediction\ Error\ (t)\ = \frac{Estimated\ P\ (t) - Real\ Price\ (t)}{Real\ Price\ (t)} * 100\% \qquad (6.1)$$

Table 6.10: Mean of daily errors

	Average of daily errors, %	V1	V2	V3	V4	V5	V6	V7	Min
Case 1	In sample	5.34	6.77	4.59	2.74	0.09	1.3	***0.05***	**0.05**
1&2 Vs. 3&4	Out sample	0.13	9.83	***-0.71***	4.18	2.5	1.56	1.29	**-0.71**
Case 2	In sample	2	1.79	1.72	1.34	-0.1	0.52	***-0.12***	**-0.12**
3&4 Vs. 1&	Out sample	4.9	2.97	3.67	-0.69	***-2.67***	-0.22	-1.62	**-2.67**
Case 3	In sample	2.26	1.95	3.37	2.01	***-0.33***	1.55	0.03	**-0.33**
1&3 Vs. 2&4	Out sample	28.91	27.9	40.51	11.16	***4***	18.86	8.46	**4**
Case 4	In sample	1.52	1.21	1.71	1.43	***-0.34***	1.36	-0.12	**-0.34**
2&4 Vs. 1&3	Out sample	-0.08	-0.1	0.28	-0.54	-2.07	-0.62	***-2.1***	**-2.1**
Case 5	In sample	4.51	4.94	9.73	2.53	0.02	2.91	***-0.02***	**-0.02**
1&4 Vs. 2&3	Out sample	4.85	3.27	9.95	3.4	***0.29***	4.15	1.43	**0.29**
Case 6	In sample	0.97	0.87	0.72	0.59	0.1	0.39	***-0.02***	**-0.02**
2&3 Vs. 1&4	Out sample	0.15	0.2	-0.78	-0.02	0.01	-1.65	***-2.08***	**-2.08**
Case 7 Whole weekdays	In sample	5.43	5.56	1.66	1.18	***-0.02***	1.1	0.15	**-0.02**
	Average of all average daily errors	**4.68**	**5.17**	**5.88**	**2.25**	**0.11**	**2.4**	**0.41**	

Table 6.11: Standard deviation of daily errors

	SD of daily errors	V1	V2	V3	V4	V5	V6	V7	Min
Case 1	In sample	11.87	12.7	11.83	8.36	***7.96***	8.37	8.24	**7.96**
1&2 Vs. 3&4	Out sample	5.37	10.12	5.4	4.93	4.96	***4.41***	4.68	**4.41**
Case 2	In sample	3.71	4.2	3.68	4.32	4.34	***3.49***	3.73	**3.49**
3&4 Vs. 1&	Out sample	9.91	10.33	10.59	7.86	***7.57***	8.38	8.01	**7.57**
Case 3	In sample	11.86	11.9	10.9	8.03	7.46	7.24	***6.9***	**6.9**
1&3 Vs. 2&4	Out sample	30.41	29.53	44.37	10.71	***5.93***	22.52	9.51	**5.93**
Case 4	In sample	4.73	***4.58***	4.76	4.63	4.93	4.67	5.1	**4.58**
2&4 Vs. 1&3	Out sample	8.89	9.25	9.04	7.67	7.39	7.43	***7.02***	**7.02**
Case 5	In sample	11.42	12.56	11.74	8.68	***8.1***	8.85	8.33	**8.1**

1&4 Vs. 2&3	Out sample	7.98	7.3	7.97	5.72	4.84	4.77	***4.32***	**4.32**
Case 6	In sample	3.15	3.11	***3.06***	4.34	4.51	3.48	3.89	**3.06**
2&3 Vs. 1&4	Out sample	***7.34***	7.78	8.24	8.06	7.94	8.06	8.02	**7.34**
Case 7 Whole weekdays	In sample	8.23	8.54	8.02	6.33	6.23	***6.15***	6.15	**6.15**
	Average of SD of daily errors	**9.61**	**10.15**	**10.74**	**6.9**	**6.32**	**7.52**	**6.46**	

It is noticeable that hybrid models using mark-up L (V5 and V7) perform the best according to this criteria when having the smallest mean and SD of daily errors most frequently. More specifically, V5 has the smallest mean and SD daily errors in 6/ 13 cases and 4/ 13 cases respectively, followed by 5/ 13 cases and 3/ 13 cases of V7. Moreover, by looking at the average of mean of daily errors, V5 and V7 models dominate others with less than 0.5% while for time series model (V1) and UC models (V2,V3), this value goes up to roughly above to 5%. Similarly, V5 and V7 have the smallest average of SD of daily errors, which are roughly 40% smaller than the pure models (V1, V2, V3) and 10% smaller than the hybrid models with mark-up M (V4 and V6). In short, V5 and V7 could be chosen as the best model based on the criteria of mean and standard deviation of daily errors.

6.2.3. Mean and standard deviation of daily absolute errors

Even though the second criteria in the previous section processes a useful insight into the performance of different model, its most obvious drawback is that the positive and negative errors in each period cancel each other out, thus misleading conclusions about forecasting accuracy. There is another tools with a similar calculation that overcomes this problem is simply by looking at the daily absolute errors. Table 6.12 and Table 6.13 recap the mean and SD of these errors. Detailed calculation could be found in Appendix F.

Table 6.12: Mean of daily absolute errors

	Average of daily absolute errors, percent	**V1**	**V2**	**V3**	**V4**	**V5**	**V6**	**V7**	**Min**
Case 1	In sample	25.75	28.64	25.82	11.67	10.25	9.5	***8.29***	**8.29**
1&2 Vs. 3&4	Out sample	20.92	29.08	21.1	11.01	10.04	8.36	***7.89***	**7.89**
Case 2	In sample	13.79	14.15	12.9	10.09	9.52	7.84	***7.34***	**7.34**
3&4 Vs. 1&	Out sample	17.48	17.11	16.48	11.03	10.54	9.53	***8.44***	**8.44**

Case 3	In sample	24.55	24.56	36.27	12.15	10.25	11.15	***8.65***	**8.65**
1&3 Vs. 2&4	Out sample	47.7	47.12	67.53	18.62	***11.3***	25.17	13.19	**11.3**
Case 4	In sample	13.45	13.54	12.37	10.12	9.75	7.56	***7.15***	**7.15**
2&4 Vs. 1&3	Out sample	15	14.92	13.97	10.71	10.19	9.11	***8.52***	**8.52**
Case 5	In sample	27.65	29.72	27.95	13.41	11.38	12.1	***9.85***	**9.85**
1&4 Vs. 2&3	Out sample	25.75	27.47	25.71	11.29	9.27	10.01	***7.42***	**7.42**
Case 6	In sample	7.06	6.79	***6.07***	8.82	9.01	6.37	6.44	**6.07**
2&3 Vs. 1&4	Out sample	10.22	10.12	9.01	11.05	10.95	8.92	***8.78***	**8.78**
Case 7 Whole weekdays	In sample	19.45	20	18.39	10.73	9.98	8.66	***7.84***	**7.84**
	Average of all average daily absolute errors	**20.67**	**21.79**	**22.58**	**11.59**	**10.19**	**10.33**	**8.45**	

Table 6.13: Standard deviation of daily absolute errors

	SD of daily absolute errors	**V1**	**V2**	**V3**	**V4**	**V5**	**V6**	**V7**	**Min**
Case 1	In sample	4.27	4.78	***4.18***	5.71	5.72	5.34	5.81	**4.18**
1&2 Vs. 3&4	Out sample	4.41	6.74	4.3	3.05	2.53	***2.47***	2.82	**2.47**
Case 2	In sample	3	2.16	2.19	2.29	2.08	***1.86***	2.32	**1.86**
3&4 Vs. 1&	Out sample	4.1	***3.86***	4	5.03	5.34	4.82	5.38	**3.86**
Case 3	In sample	4.98	4.6	5.15	4.19	4.5	***3.77***	4.06	**3.77**
1&3 Vs. 2&4	Out sample	32.84	32.09	45.51	10.61	***5.13***	22.79	9	**5.13**
Case 4	In sample	2.77	***2.06***	2.43	2.82	2.84	2.89	3.19	**2.06**
2&4 Vs. 1&3	Out sample	4.23	***4.19***	4.32	4.86	5.03	4.8	5.2	**4.19**
Case 5 1&4 Vs. 2&3	In sample	5.89	4.84	6.3	4.44	4.76	***4.35***	4.65	**4.35**
	Out sample	6.68	5.3	7.1	5.2	***3.44***	4.35	3.73	**3.44**
Case 6	In sample	2.44	***2.37***	2.46	2.73	2.72	2.73	2.7	**2.37**
2&3 Vs. 1&4	Out sample	***4.46***	4.52	5.13	4.92	4.91	5.57	5.64	**4.46**
Case 7 Whole weekdays	In sample	4.63	***3.84***	4.02	4.06	3.96	3.85	4.15	**3.84**
	Average of SD of daily absolute errors	**6.52**	**6.26**	**7.47**	**4.61**	**4.07**	**5.35**	**4.51**	

It is clear that V7 dominates other models in terms of having the smallest daily absolute errors 11/ 13 times, followed by V5 and V3, and thus has the smallest value of average of all average daily absolute errors. In terms of SD of daily absolute errors, it is interesting that V2 has the smallest value most frequently, i.e., 5/ 13 times. However, the model that has the smallest average of SD of daily absolute error is model V5 of 5.35 compared to 6.52 of model V1. Model V7 does not outperform any other model in terms of this SD. As a conclusion, overall V5 perform the best in terms of this criteria.

In this section, a total of seven models have been compared based on three criteria, and the result from MIP approach with mark-up L (V5) has proved its prediction capacity and is the most accurate model, which outperforms the pure time series model (V1) or the pure UC models (V2 and V3). Thus, V5 will be simulated in the next section of the chapter with different wind loads. For further analysis, MIP approach with markup M (V4, recommended from first criteria) and RMIP approach with markup L (V7, recommended from the second criteria) should also be used to do the sensitivity analysis to have robust conclusions.

6.3. Sensitivity analysis with wind variation

From the literature review in chapter 2, increase in wind generation lowers the wholesale electricity prices and at the same time tends to increase price variation. In Texas, it has been identified in May 2010 that 10% increase in the installed capacity of wind results in about 1% increase of price variance [2]. Analogously, this sensitivity analysis will assess the changes in terms of price level and variance.

As observed in the first part of this chapter, wind generation evidently has an impact on electricity prices through the coefficient parameters in the regression model, given fixed inputs of other explanatory variables. However, different wind input will not only alter the value of net load, but also the EP_MIP, EP_RMIP, as well as the markups from the UC models. Thus, sensitivity analysis with different wind scenarios is crucial. First, the extreme case of having wind generation, where thermal units are the only source of electricity supply, should be considered. And on the opposite side is the case with a very large wind integration. ERCOT system has a target of 35% of renewable energy by 2020[1], while there was around 7% of wind generation providing load demand in August 2014[2] as shown in Table 6.14. Regarding future uncertainty and growth (e.g., demand, fuel price, and generation's installed capacity), input data for the models would be different. However, simulating the best obtained model from previous section with threefold and fourfold increase of wind output could provide interesting insights into what might be the changes to electricity prices, given the high reliability of the model's estimated

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[1] http://library.constantcontact.com/download/get/file/1103623545016-645/20.+MemNews_Two+New+Wind+Contracts+Increase+Austin+Energy+PDF.pdf

[2] http://mis.ercot.com/misapp/GetReports.do?reportTypeId=13424&reportTitle=Hourly%20Aggregated%20Wind%20Output&showHTMLView=&mimicKey

prices and how close it resembles the real prices as presented in chapter 5, which is also the 2nd research sub-question proposed in chapter 1.

Table 6.14: Ratio of Wind/Load for ERCOT in August 2014, Percent

	% of win output /load
Max	20.20 %
Min	0.13 %
Average	6.61 %
Median	5.73 %

Based on model V5, an estimation of prices is calculated using equation (3.51) and (3.52a) as followings:

Model 5 (V5):

$$Estimated\ L(t) = \alpha + \beta_1 * L(t-24) + \beta_2 * NL(t) + \beta_3 * [NL(t)]^2 \tag{3.51}$$

$$Estimated\ P(t) = EP\_MIP/(1 - Estimated\ \ L(t)) \tag{3.52a}$$

The analysis in this section is done as follows:

- Step 1: Fit the regression model V5 with the base case to obtain the initial estimated prices
- Step 2: Run the UC model with increased or decreased wind load, to obtained the new marginal costs
- Step 3: Fit the regression model V5 with new marginal cost to obtain a new estimated prices
- Step 4: Compare the new and initial estimated prices

Regarding step 3, information of markup L at time (t-24), which is defined as $\frac{\mathrm{P(t-24) - EP\_MIP(t-24)}}{P(t-24)}$, is required estimate the markup L at time t. However, when simulating the model with different scenarios wind generation, the real value of $\mathrm{P(t-24)}$ would not be available and so is L (t-24). Hence some adjustments are made based on the estimated L from the base case (original wind output), shown in equation (6.1).

$$\begin{aligned} &New\ Estimated\ L(t) \\ &\quad = Initial\ Estimated\ L(t) + \beta_2 * [New\ NL(t) - Initial\ NL(t)] \\ &\quad + \beta_3 * ([New\ NL(t)]^2 - [Initial\ NL(t)]^2) \end{aligned} \tag{6.1}$$

Based on the description above, the following three subsections present the results obtained from simulating the model with three scenarios: no wind, a threefold increase of wind and a fourfold increase of wind respectively. Additionally, as seen in Figure 6.6 below, the total errors of predicting model with different wind loads consist of the model prediction error and the impact of wind on electricity prices. And the later one is of our focus, thus will be examined in each of the following subsections.

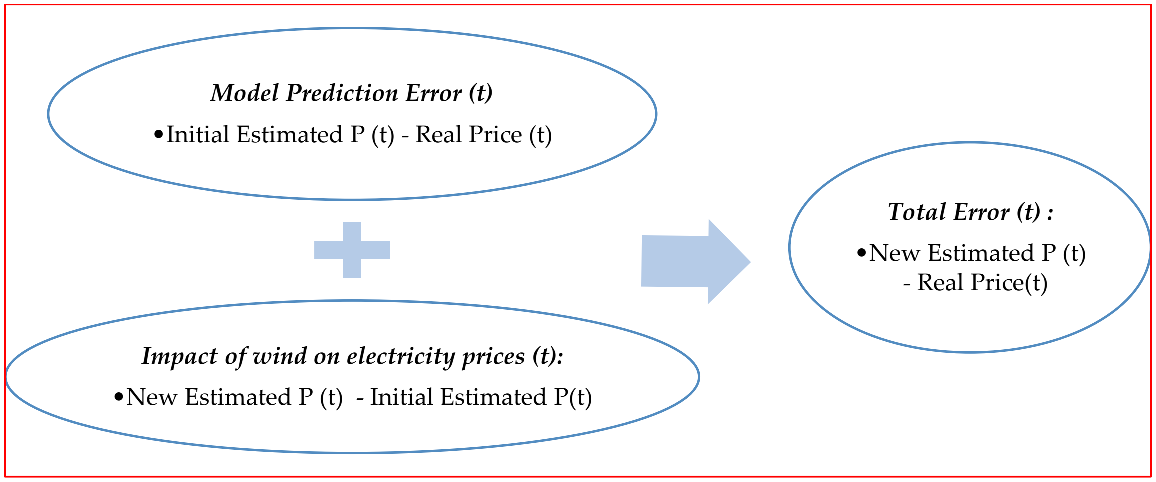

Figure 6.6: Total errors with changed wind loads

For consistency throughout this section, the summary of notations used is shown in Table 6.15:

Table 6.15: Summary of notations in section 6.3

Notation	Description
EP_V5(t)	Predicted value of real price with initial wind load using model V5 at time t
EP1_V5(t)	Predicted value of real price with no wind using model V5 at time t
EP2_V5(t)	Predicted value of real price threefold increase of wind load model V5 at time t
EP3_V5(t)	Predicted value of real price fourfold increase of wind load model V5 at time t

6.3.1. Model without Wind Generation

Predicted prices without wind have been calculated. The impact of wind generation on electricity prices level and deviation will be studied through the difference of new and initial estimated prices, whose values are shown in Figure 6.7 for an overview and Figure 6.8 for a more detailed picture.

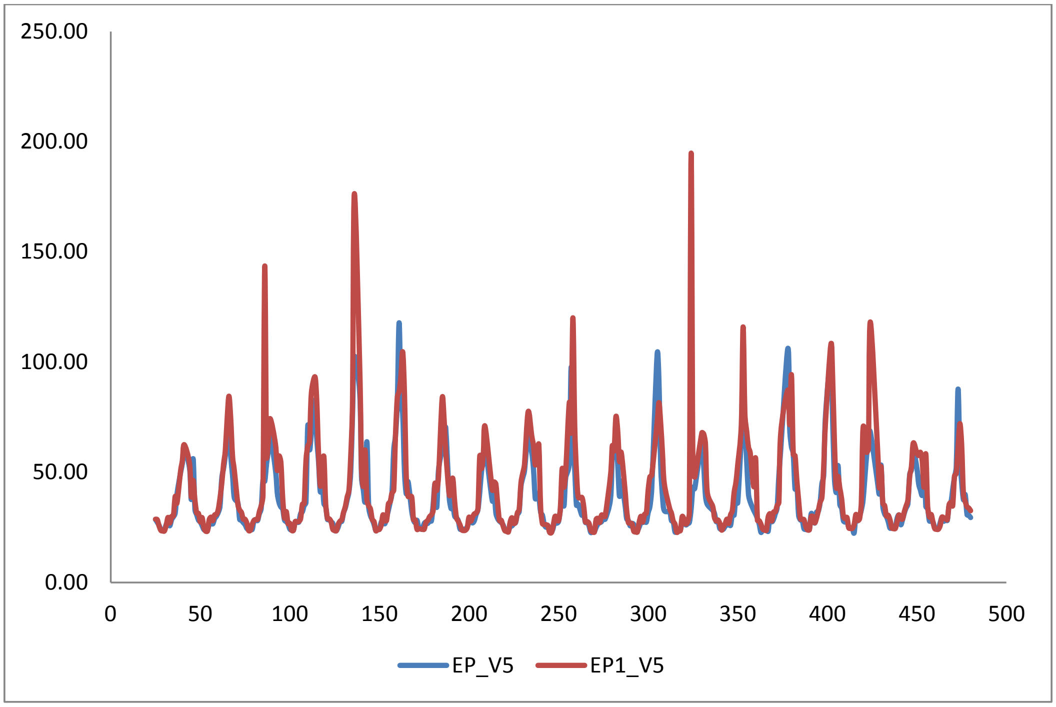

Figure 6.7: Predicted prices with initial wind load VS. without wind

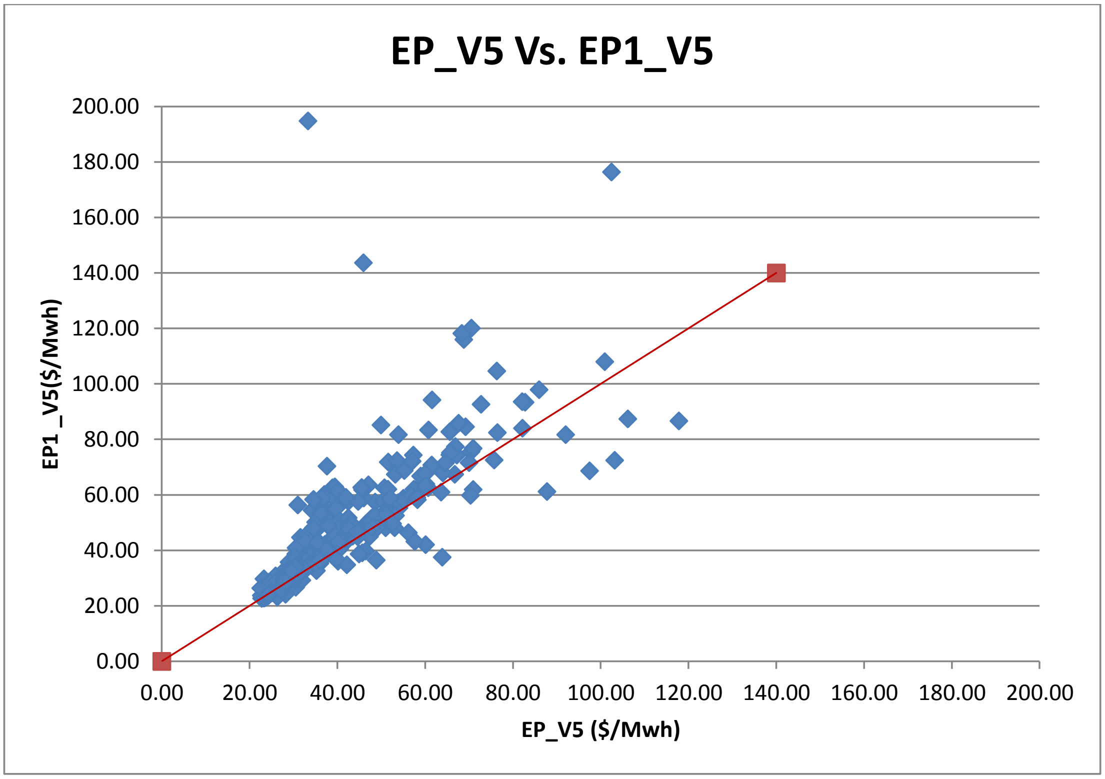

Figure 6.8: Scatter plot of predicted prices with initial wind load VS. without wind

From the first figure, it is observed that the EP1_V5 and EP follow the same pattern and have the same price floor during off peak hours. But most of the time EP1_V5 is higher. The price gap is most significant during the peak hour, e.g., a difference of roughly 70 $/ Mwh in prices is observed at period 136. Additionally, most of the points fall above the 45 degree line in the second figure, meaning that EP1_V5 is generally higher than EP_V5.

Table 6.16: Mean and standard deviation of predicted prices with initial wind load VS. without wind

	EP_V5	EP1_V5	% changes
mean	39.96	41.79	4.57 %
std dev	19.64	21.80	10.99 %

As expected, shown in Table 6.16, in the system without wind, the mean of electricity price goes up by roughly 5% due to the dispatch of more expensive units to serve higher net load. At the same time, its deviation increases by 11%. This finding deviates from the literature presented in Chapter 2, which argued that increased wind generation increases price variance. However, Figure 6.7 shows a significantly greater gap between the prices during off-peak and peak hours. Since the same base load units are dispatched in both cases so the price during off-peak hours mostly stays the same. However, in the case without wind generation, during the peak hours, more expensive marginal cost units are dispatched into the system, thus leading to higher prices during these periods, increasing the overall price variance. When the percentage of differences between two predicted prices are of the focus, it is observed from Table 6.17 that on average, the difference is around 11%, and 50% of the time the difference is around 4.4 %.

Table 6.17: Differences of predicted prices with initial wind load VS. without wind

	$\frac{\text{EP1\_V5(t)}-\text{EP\_V5(t)}}{\text{EP\_V5(t)}}$, percent
Average	10.73 %
Median	4.44 %

A simple linear regression model is built with the new predicted price in case without wind as a dependent variable and the initial predicted price is an independent variable. A coefficient of 1.082 proves an increase in predicted prices in case without wind, shown in equation (6.2).

$$\boxed{EP1\_V5\,(t) = 1.1775 + 1.082 * EP\_V5\,(t) \qquad (6.2)}$$

6.3.2. Model with threefold increase of wind generation

Similarly, predicted prices without a threefold increase of wind generation have been calculated. The new estimated prices EP2_V5 and the initial predicted price EP_V5 of August, 2014 in ERCOT system are depicted in Figure 6.9 and for an overview and Figure 6.10 for a detailed comparison.

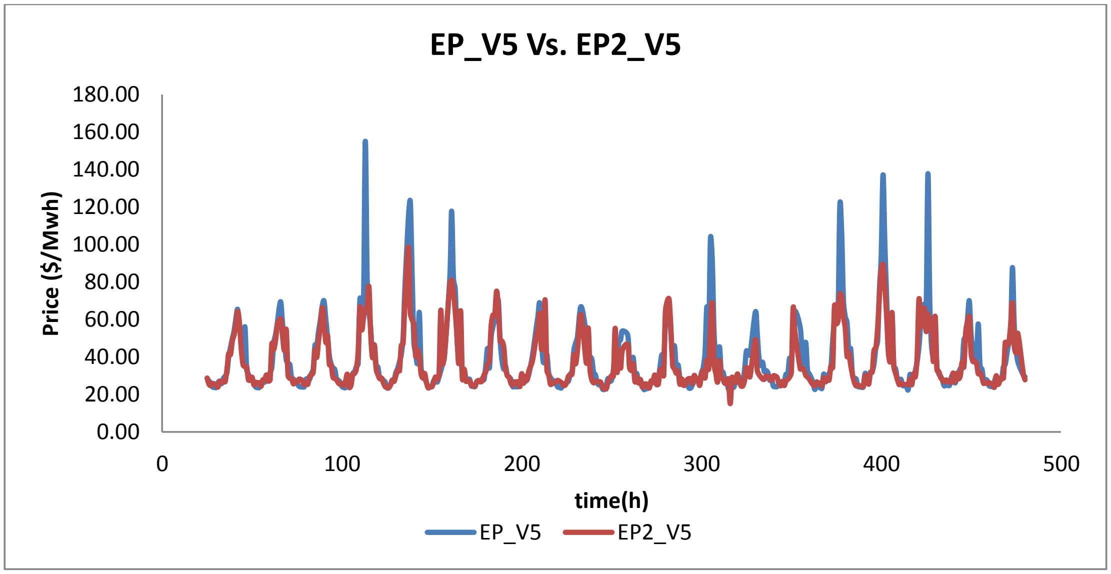

Figure 6.9: Estimated Price with initial wind load Vs. with a threefold increase of wind

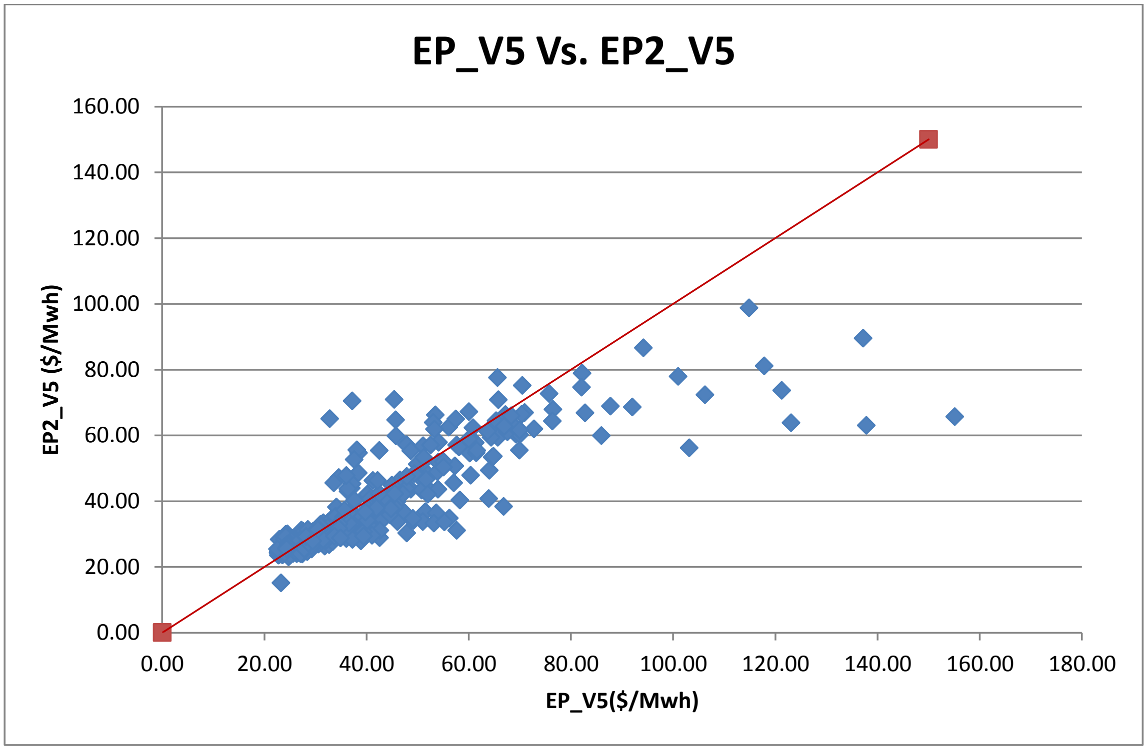

Figure 6.10: Scatterplot of estimated Price with initial wind load Vs. with a threefold increase of wind

General observation is that EP_V5 is higher than EP2_V5, especially at period 316, the new estimated price could go down to below 16 $/ MWh, compared to the price floor of 35 $/ MWh of EP_V5. More clearly, most of the points in the second Figure fall below the 45 degree line.

Table 6.18: Mean and standard deviation of predicted prices with initial wind load VS. with threefold wind generation

	EP_V5	**EP2_V5**	**% changes**
mean	39.96	36.49	-8.69 %
std dev	19.64	14.28	-27.31 %

In the system with threefold increase of wind, the mean and deviation of electricity prices decreases by roughly 8.7% by displacing high marginal cost units and 27 % respectively, which are explained by the logical explanation in the previous section, Table 6.18. More specifically, as observed from Figure 6.9, the price floor during off-peak hours mostly remains unchanged, while the price during peak period lowers significantly, thus the deviation throughout the study period is lower. Summary of the percentage of the difference between EP_V5 and EP2_V5 is shown in Table 6.19. On average, the difference of new and original estimated price is about -3.2%, and 50% of the time, it is -3.8 %. This observation could be confirmed with a coefficient of 0.64 in a regression model with the new and initial predicted prices as dependent and independent variables respectively (6.3).

Table 6.19: Difference of estimated prices without wind generation and with initial wind load

	$\frac{EP2\_V5(t)-EP\_V5(t)}{EP\_V5(t)}$, percent
Average	-3.23 %
Median	-3.80 %

$$\boxed{EP2\_V5\,(t) = 11.470 + 0.64 * EP\_V5\,(t) \quad (6.3)}$$

6.3.3. Model with fourfold increase of wind generation

UC model was run again with a fourfold increase of wind generation, a new predicted prices EP3_V5 are calculated. The difference between this value and initial estimated prices will be of the study focus. The comparisons of EP3_V5 and EP_V5 are both showed in Figure 6.11 and Figure 6.12.

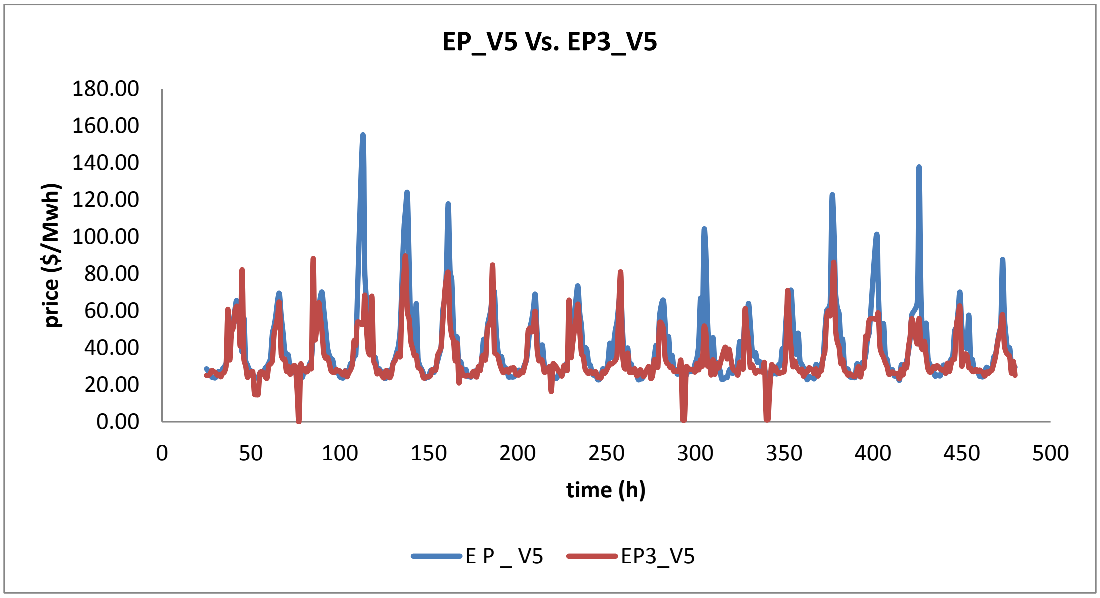

Figure 6.11: Estimated Price with initial wind load Vs. with a fourfold increase of wind

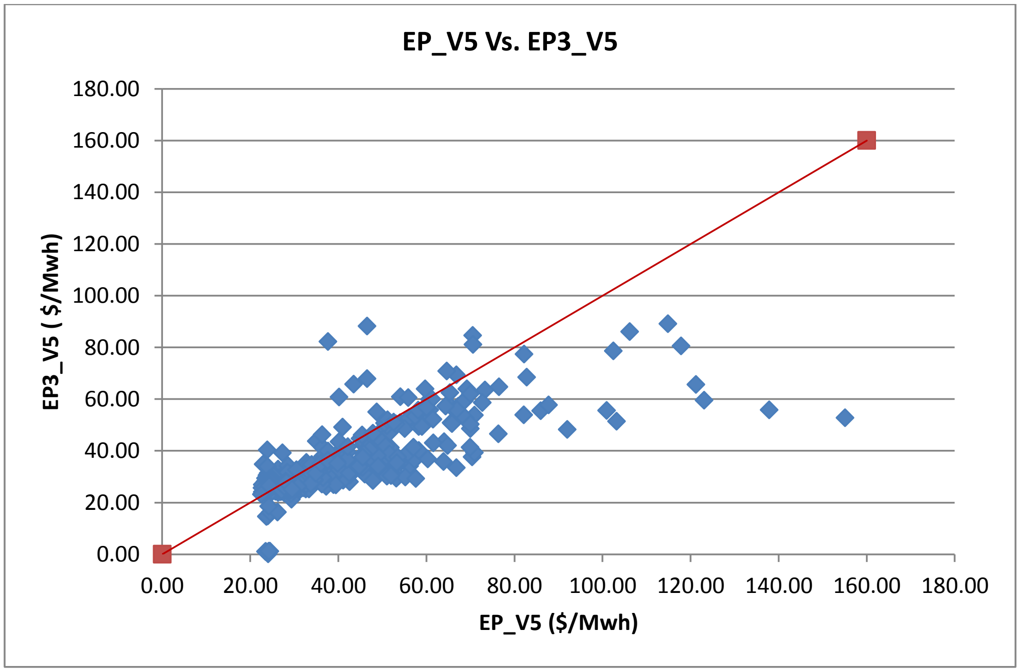

Figure 6.12: Scatter plot of estimated Price with initial wind load Vs. with a fourfold increase of wind

As expected, new estimated prices with increased wind load are much lower than the value with initial wind load. The gap between these two values is more significant in the previous case with only a threefold increase of wind generation. EP3_V5 even goes down to nearly 0 during several off-peak periods. Thus in the second Figure, most of the points fall below the 45 degree line. On average, EP3_V5 is around 14.5% lower than EP_V5 and 6.5% lower than EP2_V5. At the same time, a 33% reduction in the deviation is observed compared to the original predicted price EP_V5, see Table 6.20. In terms of difference between EP3_V5 and EP_V5, the mean is nearly 9% and half of the time it is near 8%, see Table 6.21. The coefficient of 0.54 in equation (6.4) also confirms that the new predicted price with increased wind generation is smaller than that of initial wind load.

Table 6.20: Mean and standard deviation of estimated Price with initial wind load Vs. with a fourfold increase of wind

	EP_V5	**EP3_V5**	**% changes**
mean	39.96	34.17	-14.48
std dev	19.64	13.08	-33.38

Table 6.21: Difference of estimated price with initial wind load Vs. with a fourfold increase of wind

	$\frac{\text{EP3\_V5(t)}-\text{EP\_V5(t)}}{\text{EP\_V5(t)}}$, percent
Average	-8.52 %
Median	-7.68 %

$$\text{EP3\_V5}(t) = 12.89 + 0.54 * \text{EP\_V5}(t) \qquad (6.4)$$

7. CONCLUSIONS AND RECOMMENDATIONS

In this last chapter of the thesis, the main conclusions are drawn and some guidelines for future work are outlined. Two main tasks have been conducted in the study to answer one main research question and three other sub-questions proposed in chapter 1 as follows:

Main question: What might be the impacts of wind generation upon the level of day-ahead electricity price and its volatility in a regional market in the U.S?"

Subquestions to to addressed in chapter 7	(1) What is the connection between the theoretical marginal cost and the observed electricity price?
	(2) What does changing wind load profiles influence electricity prices estimated in this study?
	(3) Is there a better way to predict the DAM electricity prices under the large presence of intermittent wind energy?

The case study used to address research questions is the ERCOT system during the month of August 2014, which presents interesting features to test the models proposed in this Master Thesis. Furthermore, what has been said about ERCOT is that: it is an independent system, which is small enough to study, but big enough to matter, which this is what makes it appealing to researchers. The order of discussion in this chapter will follow this structure of answering the research questions. The first section summarizes main conclusions and the last section presents recommendations for future work.

7.1. Conclusions

7.1.1. Relationship between theoretical marginal costs and real electricity prices

As observed from Figure 5.3, models' marginal costs follow the same pattern as the real prices with higher prices during the peak hours (in the late afternoon) and lower prices during the off-peak hours (at night and early morning. However they fail in capturing the price spikes. Results from Table 5.3 also show that real prices have a smaller mean but a much higher deviation compared to marginal costs obtained from UC models, which could also be observed graphically in Figure 5.3.

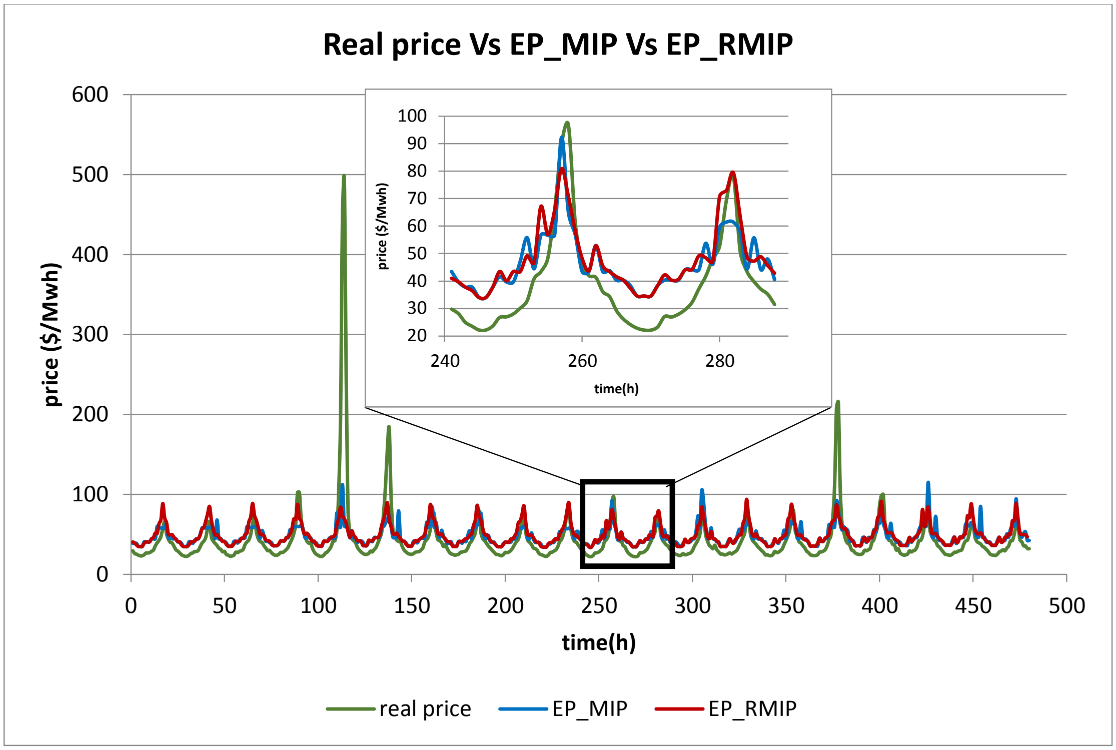

Figure 5.3: Real price vs. EP_MIP and EP_RMIP in the weekdays of August 2014.

Furthermore, in general there is a significant and positive correlation between the model's marginal costs and real prices, i.e., the higher EP_MIP/ EP_RMIP, the higher the real price. However, the coefficients of these model obtained values in the regression models, in which real price is a dependent variable, are not close to 1. There are several potential explanations proposed in section 6.2, namely: presence of other explanatory variables, presence of outliers, existence of market power, and the issue of input accuracy. To test two of the hypotheses, other two types of regression models have been built, the first one is where the only independent variable used is the model marginal cost (i.e., EP_MIP or EP/ RMIP) and in the second type, presence of outliers have also been ignored. Result shown in Table 6.3 and Table 6.4 gives coefficients of nearly 1, which could help to justify the deviation of coefficients of marginal costs from 1.

7.1.2. Influence of wind load on electricity prices estimated from the study

Statistical analysis has shown that wind has a significant impact on DAM electricity prices. Figure 7.1 summarizes the changes in terms of mean and standard deviation of predicted prices with different wind penetration (as factors of current wind value), see Table 6.16, Table 6.18 and Table 6.20. With the available generation technology by 2014, even though wind generation only contributes to roughly 7% to supply demand, the predicted prices in a system without wind could increase by nearly 11% on average and its mean could rise by around 5%. At the same time, the price tends to be more volatile with an increased in prices deviation, it is explained by a greater gap between the price during the peak and off-peak periods, as shown in Table 6.16. On the other hand, an increase of wind output will decrease the overall price level as well as its deviation. For instance, a threefold increase in wind output could, on average, lowers the price level by more than 3%. This value increases to nearly 9% with a fourfold increase of wind. Additionally, the wind also reduces average prices by roughly 9% and 15% in case of a threefold and a fourfold increase of wind respectively. Prices ‘deviation also drops by 27% and 37 % respectively, since the gap of prices during off-peak (not deviating much) and peak (reducing significantly) periods is obviously truncated, as shown in Table 6.18 and Table 6.20.

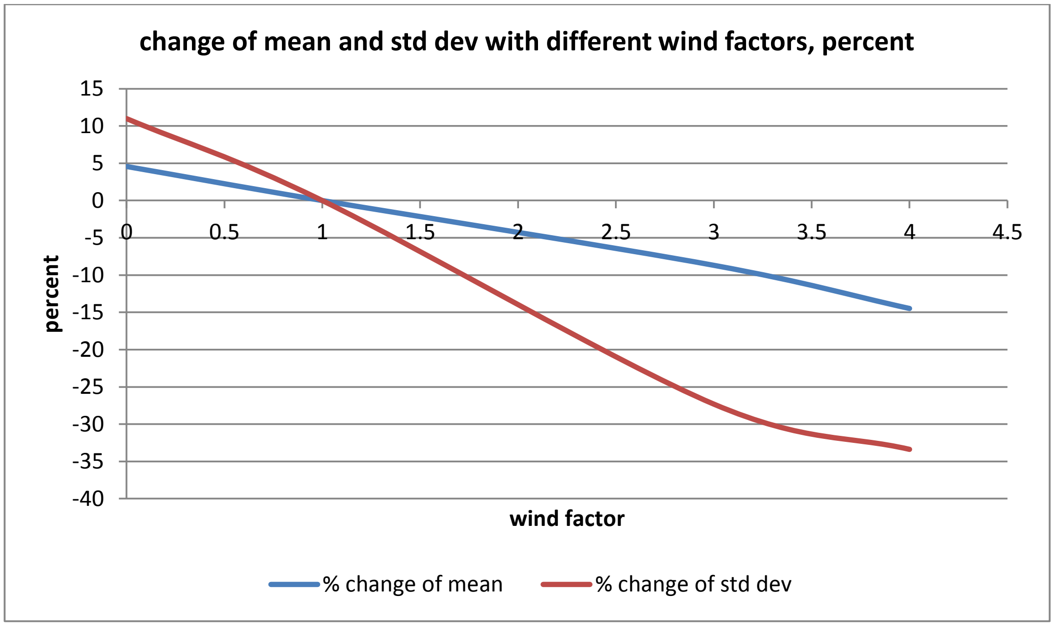

Figure 7.1: Change of mean and standard deviation with different wind factors, %

7.1.3. A better DAM electricity price forecasting approach

As identified in literature reviews, there are two main approaches to forecast electricity prices : fundamental conventional UC model and statistical models based on econometric techniques and historical prices [6]. [6] also proposed a hybrid approach combining fundamental model and econometric analysis. Thus, three main types of models consisting of a total of 7 models, Figure 6.1, have been studied and their performance have been accessed according to different criteria. Moreover, the assessment has also developed for both in-sample and out of sample data sets. In general, the hybrid models (results from UC models and mark-ups) outperform others including the pure time series models (V1) and pure UC models (V2 and V3).

More specifically, based on R^2, results from MIP approach with markup M and L (V4 and V5) have been recommended. Based on the second criteria of mean and deviation of daily error, model V5 and results from RMIP approach with markup L (V7) also perform the best. In terms of daily absolute error, V5 and V7 once again dominate the rest. Consequently, based on the overall performance of different models, a hybrid model V5 has been chosen as the best model to predict electricity prices. More specifically, in this model, an estimation of real prices is obtained using the following two equations:

Model 5 (V5):

$$Estimated\ L(t) = \alpha + \beta_1 * L(t-24) + \beta_2 * NL(t) + \beta_3 * [NL(t)]^2 \tag{3.51}$$

$$Estimated\ P(t) = EP\_MIP/(1 - Estimated\ \ L(t)) \tag{3.52a}$$

This proposed model is better than some of popular predicting approaches, e.g., the ARIMA models [16], in the sense that the predicting could be done 24 hours in advance, which is beneficial to handle the unexpected changes in the future as well as to hedge against the future risk.

7.1.4. Conclusions for the main research question

The work has been built using a state-of -art UC model and econometric analysis to derive an estimation of the real prices and thus, offers a novel approach on predicting electricity prices. Specifically, the hybrid model V5 based on EP_MIP and markup Lerner Index L is shown to perform the best amongst all, including the pure time series models and pure UC models. This model is simulated with different wind scenarios to answer the main research question of the impact of wind on electricity prices. The influence of wind on the prices as summarized briefly in previous section is obviously negative, i.e., more wind generations lowers the price level as well as price deviation and vice versa. Particularly, in the same system of the case study but without wind generation, the price could increases by 11% on average. On the contrary, if the wind is enlarged by four times, the level of prices could be expected to drop by 9% on average. Furthermore, the more wind generation is in the system, the less price deviation is observed from the model and vice versa, which could be explained graphically in Figure 6.26, Figure 6.28 and Figure 6.30. However, the literature review in Chapter 2 shows that an increase in wind generation reduces the spot electricity price level and likely enlarges its variance. The findings of this work agrees and confirm the reduction in the price level. However, it presents a different point of view for the price variance/ deviation.

7.2. Future work and extensions

Two main steps have been conducted in the study: building a DAM forecasting model and simulating the model with different wind load profiles. This opens many new questions and possible extension, which due to limited time and available data are not be able to be addressed in this work. This section will covers two sub-sections regarding the potential future work in each of the step conducted.

7.2.1. Future work on DAM forecasting model

Improving UC model could be done in many different ways. First, the model was run for a period of only one month (744 hours) and it took roughly 40 hours to finish one MIP run. However, a longer period of time is certainly required for a more convincing results, e.g., 1 year, but could pose a problem due to limited computational capability. UC problem inherently involves binary variables by definition and it is always a challenging task to build MIP-based computationally efficient models. Thus, more work needed to develop “tight” and, if possible, “compact” models so they can be solved within rational time.

Secondly, regarding the input parameters, a fixed percentage of peak demand is imposed on the reserve requirement. However, a dynamic reserve, which is also a trending topic in this field, should be considered to handle a large integration of intermittent renewable energy. This could also provide a more realistic view of the future electricity market. Consequently, the potential variations of electricity prices could be assessed more accurately.

The third improvement is regarding the obtained model marginal costs, EP_MIP and EP_RMIP. A clear gap between these values and the real prices during the off-peak hours has been identified, which was briefly clarified due to technical limits. However, other in-depth explanations should be considered. For instance, as mentioned in [7] whether or not the marginal cost in this ramp-based scheduling approach justifies the real prices in reality is still a questionable issue, further study to find out the most appropriate theoretical prices should be also done.

Next, in the econometric analysis, with a purpose of achieving a lean and compact regression analysis, explanatory variables are only derived from net load (NL) and model obtained results, which are considered under a condition of an ideal perfect electricity market. For future work, other variables related to participant's pricing and bidding strategies could also be taken into account. Furthermore, when trying to answer the first sub-question about the connection between the theoretically marginal costs and real prices, the regression model was built again for the whole weekdays (Case 7) with only one variable (EP_MIP or EP_RMIP). For a more comprehensive assessment, this analysis should be done for other 6 cases as well. The normalization of input data has not been performed in this study and will be left for future work.

Besides, as mentioned in chapter 6, six extreme points of real prices of above 200 $/ MWh have been identified. Outliers sometimes are the most interesting ones and it is important to investigate the nature of outliers before dropping them. However, their presence may have caused some disturbance in the coefficients of the regression model, thus lead to some false conclusions. The econometric analysis should be run with and without outliers, and the changes of coefficients of the later should be commented. In addition, the four-week data set has been spilt into two sets of equal size. Another common way of dividing the data is to use 70% for sampling and 30% for out-of-sample test, which is left for future study. Last but not least, the study has been applied as a weekday model, a weekend model should also be built for an exhaustive study.

7.2.2. Future work on simulating different wind load

In this second task, model V5 (EP_MIP with markup L) based on its overall performance in three criteria, has been chosen to simulate different wind loads. However, it is reminded that model V4 (EP_MIP with markup M) is also recommended if based on the first criteria of mean and deviation of the daily errors. Model V7 (EP_RMIP with markup L) also performs best based on second criteria of mean and deviation of the daily absolute errors. To obtain a comprehensive assessment of the impact of wind generation on electricity prices, model V4 and V7 should also be considered in this task. Furthermore, the wind sensitivity analysis has been done with only three wind scenarios based on a rough estimation. A wider range of circumstances should be examined, e.g., α times the increase or β times the decrease of wind generation with $0 \leq \alpha, \beta \leq 5$. Finally, the task is completed with some assumptions on the markups as well as other input variables. In order to represent the case realistically with the purpose of understanding the impact of wind for the future renewable target of 2020 of Texas, U.S., and detailed prediction on these parameters should be presented to run the case again.

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APPENDIX A : OUTPUTS OF MODEL UC_MIP

Period/Type	NUC	CLLIG	CCGT90	CCLE90	GSSUP	GSREH	SCGT90	GSNONR	SCLE90	DSL	EP_MIP
p1	5615.00	15355.10	16027.42	503.72	275.70	65.00	0.00	0.00	0.00	0.00	33.93
p2	5615.00	15355.10	13295.24	422.65	228.00	65.00	0.00	0.00	0.00	0.00	33.93
p3	5615.00	15355.10	11715.73	422.65	228.00	65.00	0.00	0.00	0.00	0.00	33.93
p4	5615.00	15355.10	10522.27	422.65	228.00	65.00	0.00	0.00	0.00	0.00	33.93
p5	5615.00	15355.10	10548.40	422.65	228.00	65.00	0.00	0.00	0.00	0.00	33.93
p6	5615.00	15355.10	11286.52	422.65	228.00	65.00	0.00	0.00	0.00	0.00	33.93
p7	5615.00	15355.10	12639.11	659.85	228.00	65.00	0.00	0.00	0.00	0.00	37.70
p8	5615.00	15355.10	13499.50	1013.00	378.17	87.50	0.00	0.00	0.00	0.00	39.59
p9	5615.00	15355.10	14993.10	958.30	228.00	110.00	0.00	0.00	0.00	0.00	37.70
p10	5615.00	15182.97	17079.12	846.36	228.00	132.50	0.00	0.00	0.00	0.00	37.70
p11	5615.00	14846.07	18741.88	1054.64	527.96	260.55	0.00	0.00	0.00	0.00	39.59
p12	5615.00	14509.17	20281.35	1073.00	912.00	561.73	0.00	0.00	0.00	0.00	43.36
p13	5615.00	13895.10	22178.18	1073.00	1106.33	1224.32	0.00	0.00	0.00	0.00	43.36
p14	5615.00	13816.30	23653.59	1073.00	1542.79	1304.34	0.00	0.00	0.00	0.00	39.59
p15	5615.00	13620.40	24337.90	1073.00	2031.05	2371.74	0.00	0.00	0.00	0.00	47.13
p16	5615.00	13424.50	25034.09	1073.00	2200.00	2328.99	86.40	0.00	159.02	0.00	43.36
p17	5615.00	12910.90	25089.90	1073.00	2200.00	2657.00	222.75	0.00	412.77	0.00	56.55
p18	5615.00	12514.45	25089.90	1073.00	2200.00	2742.50	270.00	0.00	298.01	0.00	56.55
p19	5615.00	11874.35	25089.90	1073.00	2200.00	2720.00	223.59	0.00	314.06	0.00	63.62
p20	5615.00	10899.50	24924.09	1073.00	2200.00	2456.34	87.24	0.00	0.00	0.00	43.61
p21	5615.00	9922.90	24137.90	1073.00	2200.00	1876.59	86.40	0.00	0.00	0.00	43.36
p22	5615.00	9352.90	24137.90	1073.00	2031.05	2616.13	86.40	0.00	0.00	0.00	43.36
p23	5615.00	9087.70	23763.09	1073.00	1764.65	1843.41	0.00	0.00	0.00	0.00	43.36
p24	5615.00	8449.46	21508.71	1073.00	1600.00	1607.47	0.00	0.00	0.00	0.00	43.36
p25	5615.00	8371.20	19538.64	1073.00	1109.71	665.45	0.00	0.00	0.00	0.00	39.59
p26	5615.00	8265.16	17439.68	1073.00	500.49	642.95	0.00	0.00	0.00	0.00	39.59
p27	5615.00	8213.80	15397.11	1073.00	1161.28	620.45	0.00	0.00	0.00	0.00	39.59
p28	5615.00	8213.80	15087.75	1035.45	452.00	451.80	0.00	0.00	0.00	0.00	37.70
p29	5615.00	8213.80	14920.10	535.21	452.00	429.30	0.00	0.00	0.00	0.00	37.70

p30	5615.00	8213.80	14769.81	428.65	452.00	404.30	0.00	0.00	0.00	0.00	33.93
p31	5615.00	8213.80	14995.10	553.03	452.00	440.16	0.00	0.00	0.00	0.00	37.70
p32	5615.00	8213.80	15172.11	755.41	452.00	490.16	0.00	0.00	0.00	0.00	37.70
p33	5615.00	8213.80	15936.60	1073.00	817.96	512.66	0.00	0.00	0.00	0.00	39.59
p34	5615.00	8213.80	18203.29	1073.00	1526.15	557.66	0.00	0.00	0.00	0.00	39.59
p35	5615.00	8213.80	20775.66	1073.00	1566.43	748.81	0.00	0.00	0.00	0.00	39.59
p36	5615.00	8237.46	21997.20	1073.00	1682.33	1206.76	0.00	0.00	0.00	0.00	43.36
p37	5615.00	8313.50	22919.43	1073.00	1764.65	1839.25	0.00	0.00	0.00	0.00	43.36
p38	5615.00	8419.46	23546.59	1073.00	2031.05	2448.28	0.00	0.00	0.00	0.00	43.36
p39	5615.00	8475.10	24179.90	1073.00	2200.00	2921.32	86.40	0.00	0.00	0.00	43.36
p40	5615.00	8475.10	25455.09	1073.00	2200.00	2956.48	86.40	0.00	0.00	0.00	43.36
p41	5615.00	8475.10	26058.60	1073.00	2200.00	3266.36	170.88	0.00	159.02	0.00	52.78
p42	5615.00	8475.10	26051.33	1073.00	2200.00	3440.86	222.75	0.00	370.23	0.00	56.55
p43	5615.00	8475.10	25892.79	1073.00	2200.00	3440.86	222.75	0.00	407.48	0.00	88.69
p44	5615.00	8475.10	25371.60	1073.00	2200.00	3397.65	86.40	0.00	97.96	0.00	46.02
p45	5615.00	8436.17	24351.99	1073.00	2200.00	2757.92	86.40	0.00	33.52	0.00	43.69
p46	5615.00	8330.12	23834.80	1073.00	2031.05	3255.16	222.75	0.00	33.52	0.00	56.55
p47	5615.00	8224.07	22379.61	1073.00	1764.65	3046.21	0.00	0.00	0.00	0.00	43.36
p48	5615.00	7988.36	20563.20	1073.00	1600.00	1874.63	0.00	0.00	0.00	0.00	43.36
p49	5615.00	7880.62	18996.61	1073.00	1052.45	793.81	0.00	0.00	0.00	0.00	39.59
p50	5615.00	7769.40	17261.99	1073.00	594.65	748.81	0.00	0.00	0.00	0.00	39.59
p51	5615.00	7769.40	15308.82	1073.00	674.02	703.81	0.00	0.00	0.00	0.00	39.59
p52	5615.00	7769.40	14815.11	758.40	452.00	658.81	0.00	0.00	0.00	0.00	37.70
p53	5615.00	7769.40	14545.87	428.65	452.00	525.87	0.00	0.00	0.00	0.00	33.93
p54	5615.00	7769.40	14563.10	436.15	452.00	568.89	0.00	0.00	0.00	0.00	37.70
p55	5615.00	7769.40	14563.10	679.73	452.00	627.11	0.00	0.00	0.00	0.00	37.70
p56	5615.00	7924.81	14424.74	428.65	452.00	649.61	0.00	0.00	0.00	0.00	33.93
p57	5615.00	8132.51	15910.61	531.60	452.00	677.11	0.00	0.00	0.00	0.00	37.70
p58	5615.00	8384.80	17822.61	1073.00	1017.68	722.11	0.00	0.00	0.00	0.00	39.59
p59	5615.00	8637.10	20325.09	1127.00	1574.60	813.02	86.40	0.00	0.00	0.00	39.59
p60	5615.00	8981.79	21883.80	1355.10	1682.33	1971.96	86.40	0.00	0.00	0.00	47.13
p61	5615.00	9437.70	23421.83	1457.00	1764.65	2596.52	86.40	0.00	0.00	0.00	43.36
p62	5615.00	9837.12	24631.35	1510.00	2031.05	3039.69	86.40	0.00	0.00	0.00	43.36
p63	5615.0	10221.1	25944.4	1738.1	2200.0	3256.9	86.40	0.00	0.00	0.00	43.36

	0	2	8	0	0	8					
p64	5615.00	10508.91	26695.65	1841.00	2200.00	3612.45	86.40	0.00	292.94	12.75	48.13
p65	5615.00	10600.10	26875.63	1841.00	2200.00	3833.66	222.75	0.00	931.26	25.50	56.55
p66	5615.00	10600.10	26892.60	1841.00	2200.00	3856.16	270.00	0.00	1491.49	46.77	60.32
p67	5615.00	10600.10	26892.60	1841.00	2200.00	3848.56	270.00	0.00	1273.94	72.05	66.05
p68	5615.00	10600.10	26892.60	1739.10	2200.00	3816.50	208.57	0.00	340.71	0.00	58.06
p69	5615.00	10600.10	25663.30	1457.00	2200.00	3602.60	86.40	0.00	67.03	0.00	44.11
p70	5615.00	10600.10	25159.21	1457.00	2200.00	3394.56	86.40	0.00	0.00	0.00	46.82
p71	5615.00	10518.82	23396.43	1354.10	2031.05	2469.18	0.00	0.00	0.00	0.00	45.24
p72	5615.00	10443.80	21671.41	1073.00	1340.62	1174.38	0.00	0.00	0.00	0.00	42.05
p73	5615.00	10443.80	19083.68	739.75	454.92	834.08	0.00	0.00	0.00	0.00	38.70
p74	5615.00	10443.80	15876.69	1023.07	452.00	789.08	0.00	0.00	0.00	0.00	38.70
p75	5615.00	10443.80	14265.10	823.04	452.00	744.08	0.00	0.00	0.00	0.00	38.70
p76	5615.00	10443.80	13250.31	428.65	452.00	703.64	0.00	0.00	0.00	0.00	34.83
p77	5615.00	10443.80	12557.75	428.65	452.00	713.08	0.00	0.00	0.00	0.00	34.83
p78	5615.00	10443.80	13217.33	428.65	452.00	735.58	0.00	0.00	0.00	0.00	34.83
p79	5615.00	10443.80	14517.11	973.57	480.01	775.81	0.00	0.00	0.00	0.00	40.64
p80	5615.00	10590.60	15554.20	1073.00	769.71	713.66	86.40	0.00	0.00	0.00	40.64
p81	5615.00	10737.40	17891.46	1073.00	543.98	758.66	86.40	0.00	0.00	0.00	40.64
p82	5615.00	10884.20	20857.35	1073.00	1202.58	868.66	86.40	0.00	0.00	0.00	40.64
p83	5615.00	11158.02	23253.48	1180.00	1764.65	1281.25	86.40	0.00	0.00	0.00	44.51
p84	5615.00	11438.08	25525.36	1636.19	2031.05	2069.87	86.40	0.00	0.00	0.00	44.51
p85	5615.00	11636.87	27102.29	1841.00	2200.00	3385.74	268.80	0.00	0.00	0.00	44.51
p86	5615.00	12086.96	28068.84	1841.00	2200.00	4006.64	777.00	0.00	291.76	0.00	59.99
p87	5615.00	12537.06	28414.63	1841.00	2200.00	4461.24	840.00	0.00	1099.22	25.50	58.05
p88	5615.00	12747.05	28431.60	1841.00	2200.00	4647.06	840.00	0.00	2179.11	51.00	58.05
p89	5615.00	12937.25	28431.60	1841.00	2200.00	4728.00	840.00	0.00	2562.25	51.00	58.05
p90	5615.00	13127.45	28431.60	1841.00	2200.00	4670.40	808.62	0.00	1811.23	51.00	58.05
p91	5615.00	13260.10	28431.60	1841.00	2200.00	4550.12	777.00	0.00	764.19	25.50	62.69
p92	5615.00	13260.10	27850.13	1739.10	2200.00	4186.58	86.40	0.00	0.00	0.00	45.28
p93	5615.00	13207.84	26058.60	1457.00	2200.00	3977.06	0.00	0.00	0.00	0.00	46.51
p94	5615.00	12964.50	25517.98	1457.00	2200.00	3784.19	0.00	0.00	0.00	0.00	44.51
p95	5615.00	12462.37	23545.68	1354.10	2031.05	2814.89	0.00	0.00	0.00	0.00	44.51
p96	5615.00	11711.38	21350.24	1073.00	1764.65	1667.77	0.00	0.00	0.00	0.00	44.51

p97	5615.00	10884.07	19282.43	1073.00	907.26	1043.31	0.00	0.00	0.00	0.00	40.64
p98	5615.00	10661.10	16164.86	1054.64	636.70	998.31	0.00	0.00	0.00	0.00	40.64
p99	5615.00	10661.10	14258.10	857.74	452.00	846.17	0.00	0.00	0.00	0.00	38.70
p100	5615.00	10661.10	13069.86	422.65	452.00	793.67	0.00	0.00	0.00	0.00	34.83
p101	5615.00	10661.10	12526.63	422.65	452.00	792.09	0.00	0.00	0.00	0.00	34.83
p102	5615.00	10661.10	13188.52	428.65	452.00	668.44	0.00	0.00	0.00	0.00	34.83
p103	5615.00	10661.10	13745.10	973.57	688.93	738.44	0.00	0.00	0.00	0.00	40.64
p104	5615.00	10713.39	14605.60	1073.00	1225.71	820.12	0.00	0.00	0.00	0.00	40.64
p105	5615.00	10816.48	17068.36	1031.40	634.73	919.84	0.00	0.00	0.00	0.00	38.70
p106	5615.00	10919.57	20096.08	1073.00	1355.78	1126.70	0.00	0.00	0.00	0.00	42.57
p107	5615.00	11022.66	23014.14	1180.00	1682.33	1413.40	0.00	0.00	0.00	0.00	44.51
p108	5615.00	11847.01	24911.88	1636.19	1844.17	2521.73	86.40	0.00	0.00	0.00	44.51
p109	5615.00	12504.27	26498.06	1841.00	2190.09	3825.51	103.67	0.00	138.93	0.00	50.31
p110	5615.00	13124.32	27682.63	1841.00	2633.24	4647.13	336.02	0.00	385.60	0.00	58.05
p111	5615.00	13616.58	28375.79	1841.00	2768.00	5028.50	554.25	0.00	625.60	25.50	58.05
p112	5615.00	13850.65	28431.60	1841.00	2768.00	5198.00	570.00	0.00	1368.66	51.00	58.05
p113	5615.00	13895.10	28431.60	1841.00	2768.00	5198.00	570.00	0.00	2344.24	51.00	58.05
p114	5615.00	13895.10	28431.60	1841.00	2768.00	5198.00	570.00	0.00	2501.34	51.00	58.88
p115	5615.00	13895.10	28431.60	1841.00	2768.00	5117.06	512.26	0.00	1528.95	51.00	58.22
p116	5615.00	13762.45	27949.82	1841.00	2633.24	4811.07	419.83	0.00	251.29	0.00	54.95
p117	5615.00	13493.05	26594.10	1738.10	2359.04	4175.62	0.00	0.00	0.00	0.00	44.84
p118	5615.00	13021.85	26409.79	1355.10	2200.00	3925.50	0.00	0.00	0.00	0.00	68.03
p119	5615.00	12311.80	23424.88	1073.00	2031.05	3627.31	0.00	0.00	0.00	0.00	44.51
p120	5615.00	11669.50	21274.23	1073.00	1764.65	2082.45	0.00	0.00	0.00	0.00	44.79
p121	5615.00	11235.10	18866.74	1073.00	1000.98	976.13	0.00	0.00	0.00	0.00	41.16
p122	5615.00	11235.10	16116.46	1054.64	863.94	784.98	0.00	0.00	0.00	0.00	41.16
p123	5615.00	11235.10	15059.80	528.33	452.00	714.98	0.00	0.00	0.00	0.00	39.20
p124	5615.00	11235.10	13630.37	422.65	452.00	669.98	0.00	0.00	0.00	0.00	35.28
p125	5615.00	11235.10	13166.08	422.65	452.00	628.44	0.00	0.00	0.00	0.00	35.28
p126	5615.00	11235.10	13324.51	428.65	452.00	650.94	0.00	0.00	0.00	0.00	35.28
p127	5615.00	11235.10	14343.11	973.57	562.10	686.21	0.00	0.00	0.00	0.00	41.16
p128	5615.00	11235.10	15300.60	1073.00	594.59	851.21	0.00	0.00	0.00	0.00	41.16
p129	5615.00	11286.64	17139.00	1040.03	497.58	1097.09	0.00	0.00	0.00	0.00	39.20
p130	5615.0	11650.1	19630.6	1073.0	1218.6	1235.7	0.00	0.00	0.00	0.00	43.12

	0	4	9	0	3	4					
p131	5615.00	12338.28	20733.10	1180.00	1600.00	2392.18	0.00	0.00	0.00	0.00	45.08
p132	5615.00	13216.63	22866.96	1636.19	1761.85	3219.48	0.00	0.00	0.00	0.00	45.08
p133	5615.00	13798.92	25309.59	1841.00	1923.69	4216.50	0.00	0.00	0.00	0.00	46.08
p134	5615.00	14125.57	27222.14	1841.00	2464.29	4793.17	268.80	0.00	192.54	0.00	59.76
p135	5615.00	14396.37	28414.63	1841.00	2768.00	5119.58	777.00	0.00	854.41	51.00	58.80
p136	5615.00	14588.37	28431.60	1841.00	2768.00	5198.00	840.00	0.00	2398.30	51.00	58.80
p137	5615.00	14720.10	28431.60	1841.00	2768.00	5198.00	840.00	0.00	2902.92	51.00	58.80
p138	5615.00	14720.10	28431.60	1841.00	2768.00	5198.00	840.00	0.00	2747.89	51.00	59.63
p139	5615.00	14720.10	28431.60	1841.00	2768.00	5175.50	802.72	0.00	1594.16	51.00	60.05
p140	5615.00	14720.10	28115.63	1841.00	2768.00	4881.90	306.48	0.00	251.29	0.00	55.88
p141	5615.00	14675.65	26922.48	1739.10	2633.24	3173.73	86.40	0.00	0.00	0.00	45.08
p142	5615.00	14418.92	25618.60	1457.00	2359.04	3460.64	184.50	0.00	0.00	0.00	54.88
p143	5615.00	13946.04	23282.98	1354.10	2031.05	2845.93	86.40	0.00	0.00	0.00	49.04
p144	5615.00	13311.24	20357.91	1073.00	1736.90	1651.56	86.40	0.00	0.00	0.00	41.53
p145	5615.00	12575.10	17983.96	1073.00	862.92	1065.99	86.40	0.00	0.00	0.00	41.90
p146	5615.00	12575.10	15440.07	965.53	452.00	966.27	86.40	0.00	0.00	0.00	39.90
p147	5615.00	12575.10	13715.10	694.43	452.00	819.59	86.40	0.00	0.00	0.00	39.90
p148	5615.00	12575.10	12602.98	428.65	452.00	628.44	86.40	0.00	0.00	0.00	35.91
p149	5615.00	12575.10	11613.86	422.65	452.00	605.94	86.40	0.00	0.00	0.00	35.91
p150	5615.00	12575.10	12312.48	422.65	452.00	628.44	86.40	0.00	0.00	0.00	35.91
p151	5615.00	12575.10	13967.11	473.53	452.00	664.20	86.40	0.00	0.00	0.00	37.91
p152	5615.00	12678.19	14672.60	988.81	544.24	709.20	86.40	0.00	0.00	0.00	41.90
p153	5615.00	12781.28	16414.73	1054.64	727.11	754.20	86.40	0.00	0.00	0.00	41.90
p154	5615.00	12884.37	19223.21	1126.00	1397.85	878.13	86.40	0.00	0.00	0.00	41.90
p155	5615.00	13292.26	21915.71	1354.10	1682.33	1897.31	86.40	0.00	0.00	0.00	45.89
p156	5615.00	13960.63	24291.39	1511.00	1844.17	3321.12	0.00	0.00	0.00	0.00	45.89
p157	5615.00	14404.59	26611.09	1739.10	2190.09	4130.24	96.00	0.00	0.00	0.00	55.86
p158	5615.00	14919.29	27935.65	1841.00	2633.24	4651.27	220.33	0.00	326.95	12.75	55.86
p159	5615.00	15253.14	28414.63	1841.00	2768.00	4864.10	386.40	0.00	1123.83	25.50	59.85
p160	5615.00	15355.10	28431.60	1841.00	2768.00	4941.32	522.75	0.00	1833.09	51.00	59.85
p161	5615.00	15355.10	28431.60	1841.00	2768.00	4978.00	570.00	0.00	2049.96	51.00	59.85
p162	5615.00	15355.10	28431.60	1841.00	2768.00	4978.00	570.00	0.00	1810.21	51.00	59.85
p163	5615.00	15355.10	28431.60	1841.00	2768.00	4955.50	485.47	0.00	923.02	51.00	61.03

p164	5615.00	15223.37	28115.63	1841.00	2633.24	4814.14	86.40	0.00	171.42	0.00	56.74
p165	5615.00	14819.91	27281.10	1738.10	2359.04	3594.67	86.40	0.00	0.00	0.00	45.89
p166	5615.00	14241.81	26986.79	1355.10	2200.00	3994.69	86.40	0.00	0.00	0.00	45.89
p167	5615.00	13546.45	25133.79	1073.00	2031.05	2974.33	0.00	0.00	0.00	0.00	45.89
p168	5615.00	12800.10	22552.41	1073.00	1764.65	1479.47	0.00	0.00	0.00	0.00	45.60
p169	5615.00	12800.10	19651.06	1073.00	992.42	964.50	0.00	0.00	0.00	0.00	41.37
p170	5615.00	12800.10	17575.73	953.63	452.00	824.78	0.00	0.00	0.00	0.00	39.40
p171	5615.00	12800.10	16009.11	883.01	452.00	680.94	0.00	0.00	0.00	0.00	39.40
p172	5615.00	12800.10	15408.00	428.65	452.00	628.44	0.00	0.00	0.00	0.00	35.46
p173	5615.00	12800.10	15118.43	428.65	452.00	633.46	0.00	0.00	0.00	0.00	35.46
p174	5615.00	12800.10	15596.42	428.65	452.00	660.96	0.00	0.00	0.00	0.00	35.46
p175	5615.00	12851.64	15866.10	973.57	1161.04	805.16	0.00	0.00	0.00	0.00	41.37
p176	5615.00	12903.19	16889.26	1073.00	888.11	1059.53	0.00	0.00	0.00	0.00	41.37
p177	5615.00	12954.73	18579.80	1073.00	1161.12	1207.75	0.00	0.00	0.00	0.00	41.37
p178	5615.00	13006.28	21772.61	1073.00	1600.00	1396.44	0.00	0.00	0.00	0.00	45.31
p179	5615.00	13804.17	24455.36	1126.00	1679.52	2093.65	0.00	0.00	0.00	0.00	45.31
p180	5615.00	14241.81	26073.33	1354.10	1841.37	3492.07	0.00	0.00	0.00	0.00	45.31
p181	5615.00	14819.91	27657.53	1457.00	2197.89	4239.08	268.80	0.00	25.11	0.00	45.31
p182	5615.00	15223.37	28692.63	1511.00	2599.05	4999.03	777.00	0.00	548.25	0.00	76.83
p183	5615.00	15355.10	29008.60	1739.10	2768.00	5106.60	840.00	0.00	1523.88	51.00	59.10
p184	5615.00	15352.35	29008.60	1841.00	2768.00	5161.32	840.00	0.00	1993.10	51.00	59.10
p185	5615.00	15310.65	29008.60	1841.00	2768.00	5198.00	840.00	0.00	1941.12	60.08	112.36
p186	5615.00	15167.78	29008.60	1841.00	2768.00	5198.00	840.00	0.00	1817.91	38.25	60.72
p187	5615.00	15024.90	28855.63	1841.00	2768.00	5145.41	781.68	0.00	874.63	38.25	59.27
p188	5615.00	14670.40	27829.60	1636.19	2633.24	4832.17	379.38	0.00	207.37	0.00	57.61
p189	5615.00	14530.15	26440.90	1073.00	2359.04	4243.58	86.40	0.00	0.00	0.00	45.64
p190	5615.00	14328.30	26219.28	1073.00	2200.00	4160.90	0.00	0.00	0.00	0.00	54.77
p191	5615.00	13746.30	24065.93	1073.00	2031.05	3834.68	0.00	0.00	0.00	0.00	45.31
p192	5615.00	13346.10	22053.18	1073.00	1764.65	2440.14	0.00	0.00	0.00	0.00	45.31
p193	5615.00	12721.50	20576.48	1073.00	1056.29	1262.18	0.00	0.00	0.00	0.00	41.37
p194	5615.00	12275.10	19024.40	1073.00	453.68	1055.31	0.00	0.00	0.00	0.00	41.37
p195	5615.00	12275.10	17128.01	1073.00	1168.11	837.56	0.00	0.00	0.00	0.00	41.37
p196	5615.00	12275.10	16055.10	1073.00	695.67	792.56	0.00	0.00	0.00	0.00	41.37
p197	5615.0	12275.1	16055.1	681.06	452.00	618.91	0.00	0.00	0.00	0.00	39.40

	0	0	0								
p198	5615.00	12275.10	15565.21	428.65	452.00	641.41	0.00	0.00	0.00	0.00	35.46
p199	5615.00	12275.10	15686.37	428.65	452.00	668.91	0.00	0.00	0.00	0.00	35.46
p200	5615.00	12275.10	15027.57	428.65	452.00	713.91	0.00	0.00	0.00	0.00	35.46
p201	5615.00	12275.10	16914.40	528.08	452.00	866.05	0.00	0.00	0.00	0.00	35.46
p202	5615.00	12275.10	18577.48	1073.00	1173.05	1843.78	86.40	0.00	0.00	0.00	45.31
p203	5615.00	12275.10	21894.51	1073.00	1600.00	1678.82	86.40	0.00	0.00	0.00	45.31
p204	5615.00	12697.50	23984.76	1126.00	1682.33	3125.82	86.40	0.00	0.00	0.00	45.31
p205	5615.00	13341.90	25541.27	1354.10	1764.65	3903.79	86.40	0.00	0.00	0.00	45.31
p206	5615.00	13742.10	27077.29	1511.00	2031.05	4155.13	133.65	0.00	393.31	0.00	45.31
p207	5615.00	14005.90	27712.60	1739.10	2200.00	4449.55	270.00	0.00	1107.53	38.25	86.68
p208	5615.00	14085.10	27712.60	1841.00	2200.00	4648.26	270.00	0.00	1252.79	51.00	59.10
p209	5615.00	14085.10	27712.60	1841.00	2200.00	4728.00	270.00	0.00	1449.42	51.00	59.10
p210	5615.00	14085.10	27712.60	1841.00	2200.00	4728.00	232.89	0.00	1549.90	64.62	63.04
p211	5615.00	14085.10	27695.63	1841.00	2200.00	4728.00	222.75	0.00	1248.55	73.98	72.50
p212	5615.00	14006.30	27409.60	1636.19	2200.00	4666.76	86.40	0.00	131.48	12.75	48.55
p213	5615.00	13677.75	26248.09	1073.00	2200.00	4376.89	0.00	0.00	0.00	0.00	45.64
p214	5615.00	13291.65	25428.09	1073.00	2200.00	4166.03	0.00	0.00	0.00	0.00	45.31
p215	5615.00	12483.05	23501.38	1073.00	2200.00	3900.68	0.00	0.00	0.00	0.00	57.13
p216	5615.00	11847.11	22134.90	1073.00	2031.05	2289.43	0.00	0.00	0.00	0.00	45.31
p217	5615.00	11523.11	20918.67	1073.00	1242.69	1098.29	0.00	0.00	0.00	0.00	41.37
p218	5615.00	10900.10	18242.00	1073.00	1600.00	1005.33	0.00	0.00	0.00	0.00	45.31
p219	5615.00	10900.10	15871.75	1073.00	1413.38	741.42	0.00	0.00	0.00	0.00	43.34
p220	5615.00	10900.10	14939.10	1030.50	692.33	696.42	0.00	0.00	0.00	0.00	39.40
p221	5615.00	10900.10	14893.11	681.38	452.00	628.44	0.00	0.00	0.00	0.00	39.40
p222	5615.00	10900.10	14502.65	428.65	452.00	621.21	0.00	0.00	0.00	0.00	35.46
p223	5615.00	10900.10	14454.25	428.65	452.00	789.87	0.00	0.00	0.00	0.00	35.46
p224	5615.00	10952.09	14095.88	428.65	452.00	912.00	0.00	0.00	0.00	0.00	35.46
p225	5615.00	11004.08	15513.10	697.32	452.00	1062.00	0.00	0.00	0.00	0.00	39.40
p226	5615.00	11490.47	18277.82	1073.00	1255.38	1268.86	0.00	0.00	0.00	0.00	43.34
p227	5615.00	11738.36	20898.47	1073.00	1764.65	2307.33	0.00	0.00	0.00	0.00	45.31
p228	5615.00	11986.26	23524.13	1127.00	2031.05	3486.78	86.40	0.00	0.00	0.00	45.31
p229	5615.00	12740.05	25550.74	1408.10	2200.00	4168.85	182.40	0.00	0.00	0.00	45.31
p230	5615.00	13254.25	27194.34	1738.10	2200.00	4498.72	295.64	0.00	393.31	12.75	55.16

p231	5615.00	13768.45	27695.63	1841.00	2200.00	4656.60	570.00	0.00	1309.69	51.00	59.10
p232	5615.00	14085.10	27712.60	1841.00	2200.00	4720.78	570.00	0.00	2043.51	51.00	59.10
p233	5615.00	14085.10	27712.60	1841.00	2200.00	4728.00	570.00	0.00	1740.93	76.76	63.04
p234	5615.00	14085.10	27712.60	1841.00	2200.00	4692.63	570.00	0.00	975.91	25.50	59.89
p235	5615.00	14085.10	27546.79	1841.00	2200.00	4565.88	509.29	0.00	521.38	0.00	60.10
p236	5615.00	14085.10	26880.13	1841.00	2200.00	4277.91	202.34	0.00	192.54	0.00	56.16
p237	5615.00	14005.90	25645.60	1841.00	2200.00	3085.83	0.00	0.00	0.00	0.00	45.64
p238	5615.00	13803.70	24621.09	1841.00	2031.05	3462.89	0.00	0.00	0.00	0.00	67.28
p239	5615.00	13601.50	23263.53	1719.74	1764.65	2332.45	0.00	0.00	0.00	0.00	45.31
p240	5615.00	13155.10	21847.53	1295.10	1565.13	1185.14	0.00	0.00	0.00	0.00	43.69
p241	5615.00	13155.10	20522.44	509.46	844.08	1085.42	0.00	0.00	0.00	0.00	40.00
p242	5615.00	13155.10	17460.77	1013.00	1413.09	920.70	0.00	0.00	0.00	0.00	42.00
p243	5615.00	13155.10	16491.11	1013.00	1144.54	729.55	0.00	0.00	0.00	0.00	42.00
p244	5615.00	13155.10	16239.10	673.44	452.00	659.55	0.00	0.00	0.00	0.00	40.00
p245	5615.00	13155.10	16192.52	476.65	452.00	628.44	0.00	0.00	0.00	0.00	36.00
p246	5615.00	13155.10	16759.02	476.65	452.00	650.94	0.00	0.00	0.00	0.00	36.00
p247	5615.00	13155.10	18246.60	741.47	452.00	683.32	0.00	0.00	0.00	0.00	40.00
p248	5615.00	13205.90	18423.61	1397.00	633.80	728.32	0.00	0.00	0.00	0.00	42.00
p249	5615.00	13307.50	19290.10	1397.00	878.95	838.32	0.00	0.00	0.00	0.00	41.00
p250	5615.00	13409.10	21224.79	1295.10	1679.52	1239.96	0.00	0.00	0.00	0.00	46.00
p251	5615.00	13957.10	23384.88	1072.00	1841.37	1630.76	0.00	0.00	0.00	0.00	46.00
p252	5615.00	14260.90	24583.85	1335.74	2197.89	2621.54	0.00	0.00	0.00	0.00	46.00
p253	5615.00	14564.70	26195.29	1457.00	2599.05	4106.66	86.40	0.00	97.01	0.00	47.00
p254	5615.00	14837.58	28068.84	1511.00	2768.00	4552.23	405.15	0.00	545.75	0.00	60.00
p255	5615.00	15120.70	28414.63	1739.10	2768.00	4691.32	824.25	0.00	1236.07	51.00	60.00
p256	5615.00	15305.40	28431.60	1841.00	2768.00	4728.00	840.00	0.00	2486.47	87.82	64.00
p257	5615.00	15223.37	28431.60	1841.00	2768.00	4728.00	840.00	0.00	2719.93	114.66	68.80
p258	5615.00	15031.37	28431.60	1841.00	2768.00	4728.00	840.00	0.00	1336.52	43.71	73.60
p259	5615.00	14839.37	28132.60	1841.00	2768.00	4649.58	755.75	0.00	331.73	0.00	59.65
p260	5615.00	14530.10	27082.32	1841.00	2633.24	3958.74	268.80	0.00	0.00	0.00	46.25
p261	5615.00	14318.65	25705.60	1841.00	2359.04	3493.67	0.00	0.00	0.00	0.00	46.00
p262	5615.00	13932.55	25512.79	1841.00	2031.05	3687.71	0.00	0.00	0.00	0.00	46.00
p263	5615.00	13546.45	22817.41	1841.00	1764.65	3471.73	0.00	0.00	0.00	0.00	79.49
p264	5615.0	12800.1	21236.7	1636.1	1600.0	2090.4	0.00	0.00	0.00	0.00	45.66

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p265	5615.00	12800.10	19525.53	1073.00	1121.90	1029.78	0.00	0.00	0.00	0.00	41.37
p266	5615.00	12800.10	17545.01	1073.00	540.35	930.06	0.00	0.00	0.00	0.00	41.37
p267	5615.00	12800.10	16009.11	925.35	452.00	725.34	0.00	0.00	0.00	0.00	39.40
p268	5615.00	12800.10	15223.62	422.65	452.00	680.34	0.00	0.00	0.00	0.00	35.46
p269	5615.00	12800.10	14827.47	422.65	452.00	742.48	0.00	0.00	0.00	0.00	35.46
p270	5615.00	12800.10	15160.77	422.65	452.00	758.08	0.00	0.00	0.00	0.00	35.46
p271	5615.00	12800.10	15866.10	937.93	577.50	949.23	0.00	0.00	0.00	0.00	41.37
p272	5615.00	12852.09	16862.26	1054.64	1107.78	1052.30	0.00	0.00	0.00	0.00	41.37
p273	5615.00	12904.08	18433.05	1010.90	845.01	1130.37	0.00	0.00	0.00	0.00	39.40
p274	5615.00	12956.07	20676.03	1073.00	1566.06	1313.44	0.00	0.00	0.00	0.00	43.34
p275	5615.00	13442.46	23128.67	1180.00	1761.85	2140.29	86.40	0.00	0.00	0.00	45.31
p276	5615.00	13690.36	25050.55	1636.19	1923.69	3341.61	86.40	0.00	0.00	0.00	45.31
p277	5615.00	13938.25	26340.15	1841.00	2464.29	4241.79	303.76	0.00	128.09	0.00	45.31
p278	5615.00	14207.25	27516.82	1841.00	2768.00	4628.36	811.96	0.00	614.11	0.00	65.01
p279	5615.00	14397.45	28265.79	1841.00	2768.00	4851.23	840.00	0.00	1333.10	51.00	59.10
p280	5615.00	14530.10	28431.60	1841.00	2768.00	4879.22	840.00	0.00	2196.29	105.63	63.04
p281	5615.00	14530.10	28431.60	1841.00	2768.00	4831.88	840.00	0.00	2033.19	123.63	84.32
p282	5615.00	14530.10	28431.60	1841.00	2768.00	4735.41	840.00	0.00	1597.59	12.75	59.10
p283	5615.00	14435.95	28414.63	1841.00	2768.00	4504.89	818.71	0.00	352.46	0.00	65.18
p284	5615.00	14152.83	27535.29	1841.00	2633.24	4144.60	128.11	0.00	0.00	0.00	50.56
p285	5615.00	13808.10	26328.60	1636.19	2359.04	2621.61	86.40	0.00	0.00	0.00	46.06
p286	5615.00	12869.04	26135.79	1073.00	2200.00	3311.03	129.11	0.00	0.00	0.00	55.16
p287	5615.00	12336.84	24341.58	1073.00	2031.05	2322.69	0.00	0.00	0.00	0.00	47.28
p288	5615.00	11580.24	22851.88	1073.00	1338.63	1111.04	0.00	0.00	0.00	0.00	43.11
p289	5615.00	10820.10	20711.14	638.77	452.93	922.49	0.00	0.00	0.00	0.00	39.00
p290	5615.00	10820.10	18198.68	624.63	452.00	877.49	0.00	0.00	0.00	0.00	39.00
p291	5615.00	10820.10	16126.82	973.57	465.57	832.49	0.00	0.00	0.00	0.00	40.95
p292	5615.00	10820.10	15501.97	428.65	452.00	799.59	0.00	0.00	0.00	0.00	35.10
p293	5615.00	10820.10	14908.29	428.65	452.00	605.94	0.00	0.00	0.00	0.00	35.10
p294	5615.00	10820.10	15331.54	428.65	452.00	628.44	0.00	0.00	0.00	0.00	35.10
p295	5615.00	10820.10	16344.90	973.57	533.92	689.01	0.00	0.00	0.00	0.00	40.95
p296	5615.00	10820.10	17209.90	1073.00	888.28	767.07	0.00	0.00	0.00	0.00	40.95
p297	5615.00	10820.10	19111.71	546.59	680.41	845.14	0.00	0.00	0.00	0.00	39.00

p298	5615.00	10820.10	20898.89	1073.00	1483.78	890.14	0.00	0.00	0.00	0.00	42.90
p299	5615.00	11242.50	23192.28	1073.00	1726.07	1133.04	0.00	0.00	0.00	0.00	40.95
p300	5615.00	12200.64	23894.28	1180.00	2190.09	2476.48	86.40	0.00	0.00	0.00	48.75
p301	5615.00	12732.84	25313.54	1636.19	2633.24	3451.28	173.12	0.00	0.00	0.00	54.60
p302	5615.00	13128.64	26938.02	1841.00	2768.00	3768.20	182.40	0.00	424.42	0.00	44.85
p303	5615.00	13260.10	27888.80	1841.00	2768.00	4319.14	507.00	0.00	1185.57	51.00	58.50
p304	5615.00	13260.10	28431.60	1841.00	2768.00	4613.00	570.00	0.00	1968.42	51.00	58.50
p305	5615.00	13260.10	28431.60	1841.00	2768.00	4667.72	570.00	0.00	2723.96	186.04	62.40
p306	5615.00	13260.10	28431.60	1841.00	2768.00	4722.44	570.00	0.00	2523.41	171.90	62.40
p307	5615.00	13260.10	28431.60	1841.00	2768.00	4755.92	570.00	0.00	1787.21	47.18	76.58
p308	5615.00	13181.30	28115.63	1841.00	2768.00	4645.46	429.24	0.00	182.86	0.00	55.60
p309	5615.00	12985.40	26303.90	1636.19	2768.00	4011.55	0.00	0.00	0.00	0.00	45.18
p310	5615.00	12750.57	25816.78	1073.00	2633.24	3481.32	0.00	0.00	0.00	0.00	44.85
p311	5615.00	12077.47	23109.71	1073.00	2359.04	2824.77	0.00	0.00	0.00	0.00	48.73
p312	5615.00	11781.22	19968.01	1073.00	1779.61	1553.65	0.00	0.00	0.00	0.00	40.69
p313	5615.00	11368.05	17515.49	1073.00	828.71	772.19	0.00	0.00	0.00	0.00	40.43
p314	5615.00	11056.10	14647.82	986.20	760.92	727.19	0.00	0.00	0.00	0.00	40.43
p315	5615.00	11056.10	13699.11	441.29	452.00	682.19	0.00	0.00	0.00	0.00	36.58
p316	5615.00	11056.10	12351.57	428.65	452.00	654.69	0.00	0.00	0.00	0.00	34.65
p317	5615.00	11056.10	11567.82	428.65	452.00	607.19	0.00	0.00	0.00	0.00	34.65
p318	5615.00	11056.10	11870.56	428.65	452.00	605.94	0.00	0.00	0.00	0.00	34.65
p319	5615.00	11056.10	13556.10	671.41	452.00	628.44	0.00	0.00	0.00	0.00	38.50
p320	5615.00	11056.10	14482.76	1073.00	1090.35	731.57	0.00	0.00	0.00	0.00	40.43
p321	5615.00	11056.10	16300.86	1073.00	552.31	813.25	0.00	0.00	0.00	0.00	40.43
p322	5615.00	11490.50	19018.49	1073.00	1125.57	948.68	0.00	0.00	0.00	0.00	40.43
p323	5615.00	11686.40	22141.11	1073.00	1189.43	1163.76	0.00	0.00	0.00	0.00	40.43
p324	5615.00	12105.27	24224.28	1180.00	1764.65	2387.09	86.40	0.00	0.00	0.00	44.28
p325	5615.00	12602.07	25845.13	1636.19	2031.05	3826.98	86.40	0.00	0.00	0.00	44.28
p326	5615.00	12898.32	27794.32	1841.00	2200.00	4427.49	172.80	0.00	321.97	0.00	46.20
p327	5615.00	13127.45	28431.60	1841.00	2200.00	4836.33	588.75	0.00	1105.48	38.25	57.75
p328	5615.00	13260.10	28431.60	1841.00	2200.00	4955.50	824.25	0.00	1989.02	51.00	57.75
p329	5615.00	13260.10	28431.60	1841.00	2200.00	4978.00	840.00	0.00	2839.85	51.00	57.75
p330	5615.00	13260.10	28431.60	1841.00	2200.00	4978.00	840.00	0.00	3056.40	51.00	60.25
p331	5615.0	13260.1	28431.6	1841.0	2200.0	4955.5	777.00	0.00	1386.6	51.00	58.25

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p332	5615.00	13180.90	27850.13	1841.00	2200.00	4268.93	268.80	0.00	73.45	0.00	44.53
p333	5615.00	12978.70	25573.79	1841.00	2200.00	3898.62	96.00	0.00	0.00	0.00	44.28
p334	5615.00	12674.50	24555.79	1738.10	2200.00	3852.16	0.00	0.00	0.00	0.00	51.90
p335	5615.00	11814.28	22907.31	1457.00	2031.05	2699.50	0.00	0.00	0.00	0.00	44.28
p336	5615.00	11254.31	20614.48	1457.00	1151.79	1235.26	0.00	0.00	0.00	0.00	40.16
p337	5615.00	10332.50	18027.58	1355.10	500.28	1135.54	0.00	0.00	0.00	0.00	39.90
p338	5615.00	10134.50	15158.84	1073.00	750.66	1044.23	0.00	0.00	0.00	0.00	39.90
p339	5615.00	9712.10	14641.10	616.50	452.00	788.08	0.00	0.00	0.00	0.00	38.00
p340	5615.00	9712.10	13808.21	428.65	452.00	760.58	0.00	0.00	0.00	0.00	34.20
p341	5615.00	9712.10	13324.99	482.65	452.00	713.08	0.00	0.00	0.00	0.00	34.20
p342	5615.00	9712.10	13694.79	482.65	452.00	735.58	0.00	0.00	0.00	0.00	34.20
p343	5615.00	9712.10	15314.11	716.61	452.00	772.64	0.00	0.00	0.00	0.00	38.00
p344	5615.00	9712.10	16564.30	1250.94	452.00	817.64	0.00	0.00	0.00	0.00	38.00
p345	5615.00	9786.50	18231.43	1457.00	489.62	888.35	0.00	0.00	0.00	0.00	39.90
p346	5615.00	9860.90	21293.93	1457.00	1245.27	1170.22	0.00	0.00	0.00	0.00	39.90
p347	5615.00	10060.72	23423.35	1408.10	1844.17	1956.14	0.00	0.00	0.00	0.00	43.70
p348	5615.00	10994.81	24906.33	1354.10	2190.09	3391.90	86.40	0.00	0.00	0.00	43.70
p349	5615.00	11442.15	27430.84	1457.00	2633.24	4196.90	187.90	0.00	0.00	0.00	53.20
p350	5615.00	12216.90	28831.82	1457.00	2768.00	4915.87	440.85	0.00	227.50	0.00	53.20
p351	5615.00	12719.10	29570.40	1511.00	2768.00	5164.84	824.25	0.00	966.14	0.00	57.00
p352	5615.00	13119.30	29570.40	1739.10	2768.00	5286.32	840.00	0.00	2073.30	51.00	57.00
p353	5615.00	13260.10	29570.40	1841.00	2768.00	5323.00	840.00	0.00	3278.85	51.00	57.00
p354	5615.00	13260.10	29570.40	1841.00	2768.00	5323.00	840.00	0.00	3465.82	51.00	57.83
p355	5615.00	13260.10	29553.43	1841.00	2768.00	5286.32	763.31	0.00	1764.82	51.00	58.37
p356	5615.00	13127.45	28711.60	1841.00	2768.00	5042.58	414.21	0.00	222.79	0.00	54.20
p357	5615.00	12937.25	27272.60	1841.00	2464.29	4339.20	86.40	0.00	0.00	0.00	44.03
p358	5615.00	12708.12	26093.98	1636.19	1923.69	3796.80	221.73	0.00	0.00	0.00	53.20
p359	5615.00	12290.12	23629.88	1073.00	1600.00	3589.94	213.75	0.00	0.00	0.00	53.20
p360	5615.00	12184.07	21122.88	1073.00	1600.00	2249.44	0.00	0.00	0.00	0.00	43.70
p361	5615.00	11961.10	19852.58	1073.00	900.31	1042.09	0.00	0.00	0.00	0.00	39.90
p362	5615.00	11961.10	17027.83	1073.00	914.90	997.09	0.00	0.00	0.00	0.00	39.90
p363	5615.00	11961.10	15670.10	1073.00	1231.20	765.94	0.00	0.00	0.00	0.00	39.90
p364	5615.00	11961.10	15580.73	1073.00	1194.21	695.94	0.00	0.00	0.00	0.00	39.90

p365	5615.00	11961.10	15096.11	1073.00	945.03	650.94	0.00	0.00	0.00	0.00	39.90
p366	5615.00	11961.10	14844.10	620.88	452.00	650.94	0.00	0.00	0.00	0.00	38.00
p367	5615.00	11961.10	13472.07	428.65	452.00	695.94	0.00	0.00	0.00	0.00	34.20
p368	5615.00	11961.10	13224.80	428.65	452.00	805.94	0.00	0.00	0.00	0.00	34.20
p369	5615.00	11961.10	15905.60	534.23	452.00	906.91	0.00	0.00	0.00	0.00	38.00
p370	5615.00	11961.10	18533.60	1073.00	1235.57	1504.44	86.40	0.00	0.00	0.00	39.90
p371	5615.00	11961.10	21636.10	1073.00	1764.65	2988.64	86.40	0.00	0.00	0.00	47.50
p372	5615.00	12184.07	24696.71	1127.00	2031.05	3950.11	86.40	0.00	0.00	0.00	49.40
p373	5615.00	12290.12	27174.98	1408.10	2200.00	4250.83	93.69	0.00	0.00	0.00	43.70
p374	5615.00	12396.17	28414.63	1738.10	2200.00	4580.51	412.44	0.00	683.30	38.25	62.70
p375	5615.00	12435.10	28431.60	1841.00	2200.00	4605.62	824.25	0.00	2356.80	85.03	83.60
p376	5615.00	12435.10	28431.60	1841.00	2200.00	4581.88	840.00	0.00	3180.12	164.03	128.00
p377	5615.00	12435.10	28431.60	1841.00	2200.00	4527.16	840.00	0.00	2532.98	161.41	60.80
p378	5615.00	12435.10	28431.60	1841.00	2200.00	4457.34	816.81	0.00	807.99	0.00	63.53
p379	5615.00	12435.10	28115.63	1739.10	2200.00	4083.73	308.61	0.00	0.00	0.00	45.12
p380	5615.00	12435.10	27281.10	1457.00	2200.00	3487.72	381.35	0.00	0.00	0.00	54.70
p381	5615.00	12277.10	26029.79	1457.00	2200.00	2796.05	86.40	0.00	0.00	0.00	44.45
p382	5615.00	11826.74	25315.79	1457.00	2200.00	3073.83	171.34	0.00	0.00	0.00	53.20
p383	5615.00	11235.04	24479.60	1457.00	2200.00	2849.21	0.00	0.00	0.00	0.00	45.60
p384	5615.00	10024.24	23545.68	1457.00	2031.05	1848.62	0.00	0.00	0.00	0.00	43.70
p385	5615.00	9512.50	21528.05	1457.00	1764.65	1111.64	0.00	0.00	0.00	0.00	43.70
p386	5615.00	9090.10	20239.34	1457.00	1142.58	765.94	0.00	0.00	0.00	0.00	39.90
p387	5615.00	9090.10	17246.75	1354.10	1600.00	1239.41	0.00	0.00	0.00	0.00	43.70
p388	5615.00	9090.10	17013.05	639.15	878.95	675.94	0.00	0.00	0.00	0.00	38.00
p389	5615.00	9090.10	16172.65	428.65	452.00	630.94	0.00	0.00	0.00	0.00	34.20
p390	5615.00	9090.10	16520.60	428.65	452.00	626.59	0.00	0.00	0.00	0.00	34.20
p391	5615.00	9090.10	16537.10	640.54	452.00	659.54	0.00	0.00	0.00	0.00	38.00
p392	5615.00	9090.10	16537.10	1076.60	452.00	704.54	0.00	0.00	0.00	0.00	38.00
p393	5615.00	9090.10	16941.60	1391.41	878.95	724.54	0.00	0.00	0.00	0.00	38.00
p394	5615.00	9090.10	18777.47	1457.00	1682.33	862.72	0.00	0.00	0.00	0.00	43.70
p395	5615.00	9090.10	21550.97	1457.00	1531.65	1232.23	0.00	0.00	0.00	0.00	39.90
p396	5615.00	9403.84	22688.78	1457.00	2031.05	2270.64	0.00	0.00	0.00	0.00	47.50
p397	5615.00	9958.24	24167.44	1511.00	2200.00	2581.14	86.40	0.00	0.00	0.00	60.80
p398	5615.0	10288.2	25052.6	1739.1	2200.0	2967.7	86.40	0.00	0.00	0.00	43.70

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p399	5615.00	10538.50	25584.10	1841.00	2200.00	3093.65	128.53	0.00	0.00	0.00	53.20
p400	5615.00	10600.10	26029.79	1841.00	2200.00	3141.15	86.40	0.00	192.54	0.00	47.50
p401	5615.00	10600.10	26332.60	1841.00	2200.00	3235.65	222.75	0.00	635.29	25.50	57.00
p402	5615.00	10600.10	26332.60	1841.00	2200.00	3343.00	264.12	0.00	1055.20	25.50	57.00
p403	5615.00	10600.10	26332.60	1841.00	2200.00	3496.00	221.06	0.00	873.72	12.75	61.56
p404	5615.00	10600.10	26332.60	1738.10	2200.00	3453.18	86.40	0.00	102.98	0.00	48.96
p405	5615.00	10561.17	26166.79	1457.00	2200.00	2656.40	86.40	0.00	0.00	0.00	43.70
p406	5615.00	10455.12	25452.79	1457.00	2031.05	2835.45	86.40	0.00	0.00	0.00	43.70
p407	5615.00	10349.07	22698.61	1457.00	1764.65	3370.28	168.68	0.00	0.00	0.00	53.20
p408	5615.00	10126.10	21530.68	1355.10	1191.00	2005.63	0.00	0.00	0.00	0.00	39.80
p409	5615.00	10126.10	19377.73	1073.00	1600.00	1072.28	0.00	0.00	0.00	0.00	43.47
p410	5615.00	10126.10	17720.10	1073.00	994.84	951.88	0.00	0.00	0.00	0.00	39.69
p411	5615.00	10126.10	17221.75	1065.43	452.00	841.88	0.00	0.00	0.00	0.00	37.80
p412	5615.00	10126.10	17054.10	656.89	452.00	650.94	0.00	0.00	0.00	0.00	37.80
p413	5615.00	10198.50	16467.96	482.65	452.00	628.44	0.00	0.00	0.00	0.00	34.02
p414	5615.00	10270.90	16621.42	482.65	452.00	720.94	0.00	0.00	0.00	0.00	34.02
p415	5615.00	10343.30	17088.10	1079.13	551.18	779.79	0.00	0.00	0.00	0.00	37.80
p416	5615.00	10490.10	18032.25	1457.00	1272.23	879.51	0.00	0.00	0.00	0.00	41.58
p417	5615.00	10636.90	19558.68	1457.00	1045.88	993.16	0.00	0.00	0.00	0.00	39.69
p418	5615.00	10783.70	21566.73	1355.10	1510.16	1360.07	0.00	0.00	0.00	0.00	39.69
p419	5615.00	11098.59	23691.30	1073.00	1764.65	2849.17	0.00	0.00	0.00	0.00	47.25
p420	5615.00	11413.49	25704.34	1073.00	2031.05	4033.76	0.00	0.00	100.40	0.00	55.81
p421	5615.00	11611.28	27259.45	1073.00	2200.00	4385.90	0.00	0.00	461.80	38.25	44.47
p422	5615.00	11858.08	28414.63	1180.00	2200.00	4670.13	86.40	0.00	1215.38	38.25	56.70
p423	5615.00	12104.87	28431.60	1636.19	2200.00	4688.35	222.75	0.00	649.56	25.50	56.70
p424	5615.00	12290.12	28431.60	1841.00	2200.00	4633.63	270.00	0.00	856.79	25.50	56.70
p425	5615.00	12396.17	28431.60	1841.00	2200.00	4581.88	270.00	0.00	1465.54	48.19	92.23
p426	5615.00	12435.10	28431.60	1841.00	2200.00	4527.16	270.00	0.00	1455.76	42.23	65.02
p427	5615.00	12435.10	28115.63	1841.00	2200.00	4391.78	222.75	0.00	338.67	0.00	56.87
p428	5615.00	12435.10	26102.48	1841.00	2200.00	3242.43	86.40	0.00	0.00	0.00	43.47
p429	5615.00	12435.10	24798.60	1841.00	2200.00	3115.14	86.40	0.00	0.00	0.00	43.47
p430	5615.00	12382.84	24798.60	1739.10	2031.05	3328.50	129.73	0.00	0.00	0.00	52.92
p431	5615.00	12163.60	23250.80	1354.10	1764.65	3026.78	86.40	0.00	0.00	0.00	43.47

p432	5615.00	11809.94	21532.56	1073.00	1600.00	1878.86	86.40	0.00	0.00	0.00	43.82
p433	5615.00	11298.20	19634.20	1073.00	1228.90	999.23	86.40	0.00	0.00	0.00	40.32
p434	5615.00	10875.80	17810.74	1073.00	931.21	954.23	86.40	0.00	0.00	0.00	40.32
p435	5615.00	10875.80	16055.10	674.33	452.00	909.23	86.40	0.00	0.00	0.00	38.40
p436	5615.00	10875.80	14542.79	428.65	452.00	906.73	0.00	0.00	0.00	0.00	34.56
p437	5615.00	10875.80	13222.10	428.65	452.00	738.08	0.00	0.00	0.00	0.00	34.56
p438	5615.00	10875.80	14162.96	428.65	452.00	756.06	0.00	0.00	0.00	0.00	34.56
p439	5615.00	10875.80	16476.10	764.45	452.00	778.56	86.40	0.00	0.00	0.00	38.40
p440	5615.00	10875.80	17405.30	1073.00	1003.99	813.89	86.40	0.00	0.00	0.00	40.32
p441	5615.00	10875.80	18292.75	1126.00	880.08	751.75	86.40	0.00	0.00	0.00	40.32
p442	5615.00	10875.80	19844.45	1408.10	1672.24	796.75	86.40	0.00	0.00	0.00	40.32
p443	5615.00	10899.46	21379.79	1739.10	2031.05	1020.33	86.40	0.00	0.00	0.00	44.16
p444	5615.00	11238.84	22921.41	1841.00	2200.00	2117.33	86.40	0.00	0.00	0.00	44.16
p445	5615.00	11793.24	24446.80	1841.00	2200.00	2888.02	86.40	0.00	0.00	0.00	44.16
p446	5615.00	12123.24	25750.90	1841.00	2200.00	3560.93	213.79	0.00	0.00	0.00	53.76
p447	5615.00	12373.50	26968.32	1841.00	2200.00	3828.75	86.40	0.00	394.85	0.00	46.08
p448	5615.00	12435.10	27656.79	1841.00	2200.00	4174.78	222.75	0.00	1316.98	38.25	59.52
p449	5615.00	12435.10	27712.60	1841.00	2200.00	4342.62	270.00	0.00	1944.89	66.81	61.44
p450	5615.00	12356.30	27712.60	1841.00	2200.00	4441.60	270.00	0.00	2047.19	45.61	61.44
p451	5615.00	12160.40	27712.60	1738.10	2200.00	4409.58	222.75	0.00	1105.41	12.75	57.77
p452	5615.00	11964.50	27392.82	1457.00	2200.00	3490.55	86.40	0.00	113.39	0.00	44.41
p453	5615.00	11480.36	25572.79	1457.00	2200.00	3735.20	87.82	0.00	33.52	0.00	55.76
p454	5615.00	11267.96	24927.10	1457.00	2200.00	3395.42	86.40	0.00	0.00	0.00	44.16
p455	5615.00	10893.63	22379.61	1457.00	2031.05	2987.55	86.40	0.00	0.00	0.00	48.02
p456	5615.00	10286.52	20747.92	1457.00	1618.93	1647.83	86.40	0.00	0.00	0.00	40.53
p457	5615.00	9734.07	19380.73	1457.00	758.92	932.02	86.40	0.00	0.00	0.00	40.74
p458	5615.00	9511.10	17584.64	1300.49	452.00	832.30	86.40	0.00	0.00	0.00	38.80
p459	5615.00	9511.10	15536.71	1073.00	1033.48	682.30	86.40	0.00	0.00	0.00	40.74
p460	5615.00	9511.10	14641.10	541.11	452.00	654.80	0.00	0.00	0.00	0.00	38.80
p461	5615.00	9511.10	13752.63	428.65	452.00	632.30	0.00	0.00	0.00	0.00	34.92
p462	5615.00	9511.10	14160.96	482.65	452.00	629.80	0.00	0.00	0.00	0.00	34.92
p463	5615.00	9511.10	16087.80	949.95	452.00	657.30	86.40	0.00	0.00	0.00	38.80
p464	5615.00	9583.50	17176.96	1457.00	877.92	702.30	86.40	0.00	0.00	0.00	40.74
p465	5615.0	9655.90	18102.5	1457.0	600.24	747.30	86.40	0.00	0.00	0.00	40.74

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p466	5615.00	9728.30	19944.43	1457.00	857.37	933.01	86.40	0.00	0.00	0.00	40.74
p467	5615.00	10099.56	21832.43	1457.00	1302.90	1082.38	86.40	0.00	0.00	0.00	40.74
p468	5615.00	10751.56	23552.00	1355.10	1764.65	2305.99	86.40	0.00	0.00	0.00	44.62
p469	5615.00	11382.33	25383.61	1073.00	2031.05	3366.41	86.40	0.00	0.00	0.00	44.62
p470	5615.00	11936.22	26916.84	1126.00	2200.00	4133.99	200.03	0.00	130.52	0.00	54.32
p471	5615.00	12317.37	27639.82	1354.10	2200.00	4420.46	270.00	0.00	685.05	12.75	73.27
p472	5615.00	12435.10	27712.60	1511.00	2200.00	4496.32	270.00	0.00	1375.20	51.00	58.20
p473	5615.00	12435.10	27712.60	1739.10	2200.00	4533.00	270.00	0.00	2094.51	114.36	104.76
p474	5615.00	12435.10	27712.60	1796.08	2200.00	4533.00	270.00	0.00	1959.63	97.26	90.02
p475	5615.00	12435.10	27712.60	1799.85	2200.00	4482.31	222.75	0.00	552.31	51.00	62.08
p476	5615.00	12435.10	25641.43	1738.10	2200.00	4138.65	86.40	0.00	130.52	0.00	46.12
p477	5615.00	12435.10	24924.09	1457.00	2200.00	2879.79	86.40	0.00	130.52	0.00	44.62
p478	5615.00	12373.50	24347.09	1457.00	2200.00	3419.47	222.75	0.00	291.63	0.00	58.20
p479	5615.00	12123.24	22481.05	1336.74	2200.00	2900.75	86.40	0.00	33.52	0.00	44.62
p480	5615.00	11793.24	20953.43	1013.00	2031.05	1707.98	86.40	0.00	0.00	0.00	44.62
p481	5615.00	11238.84	18170.00	1013.00	1632.03	961.44	86.40	0.00	0.00	0.00	40.74
p482	5615.00	10925.10	16462.12	931.93	772.24	861.72	86.40	0.00	0.00	0.00	40.74
p483	5615.00	10925.10	14419.76	422.65	452.00	697.00	0.00	0.00	0.00	0.00	34.92
p484	5615.00	10925.10	13256.73	422.65	452.00	669.50	0.00	0.00	0.00	0.00	34.92
p485	5615.00	10925.10	13295.88	422.65	452.00	628.44	0.00	0.00	0.00	0.00	34.92
p486	5615.00	10925.10	14122.61	422.65	452.00	655.22	86.40	0.00	0.00	0.00	34.92
p487	5615.00	10925.10	15214.76	931.93	1014.51	700.22	86.40	0.00	0.00	0.00	40.74
p488	5615.00	10977.09	16271.55	1013.00	1600.00	1077.34	86.40	0.00	0.00	0.00	44.62
p489	5615.00	11029.08	17395.83	1067.00	1436.21	815.93	86.40	0.00	0.00	0.00	40.74
p490	5615.00	11186.67	18861.00	1295.10	1291.21	951.64	86.40	0.00	0.00	0.00	40.74
p491	5615.00	11344.26	20759.95	1403.00	1645.32	1375.25	86.40	0.00	0.00	0.00	40.74
p492	5615.00	11501.86	23182.17	1491.64	1923.69	2721.13	86.40	0.00	0.00	0.00	48.50
p493	5615.00	11973.19	25177.59	1738.10	2464.29	3677.41	222.75	0.00	0.00	0.00	56.26
p494	5615.00	12493.39	27222.14	1841.00	2768.00	4381.26	231.05	0.00	0.00	0.00	54.32
p495	5615.00	13013.59	28414.63	1841.00	2768.00	4800.60	446.05	0.00	706.41	51.00	54.32
p496	5615.00	13260.10	28431.60	1841.00	2768.00	4941.32	540.00	0.00	2480.41	51.00	58.20
p497	5615.00	13260.10	28431.60	1841.00	2768.00	4978.00	540.00	0.00	3299.25	55.13	62.08
p498	5615.00	13260.10	28431.60	1841.00	2768.00	4905.95	540.00	0.00	2659.65	107.19	66.74

p499	5615.00	13260.10	28431.60	1841.00	2633.24	4746.23	485.29	0.00	915.93	25.50	59.75
p500	5615.00	13260.10	26974.32	1841.00	2359.04	4307.85	172.80	0.00	0.00	0.00	45.40
p501	5615.00	13181.30	25485.60	1841.00	2200.00	3541.76	86.40	0.00	0.00	0.00	44.62
p502	5615.00	12867.27	25319.79	1841.00	2200.00	3334.98	215.82	0.00	0.00	0.00	54.32
p503	5615.00	12363.12	24240.40	1738.10	2031.05	2001.55	86.40	0.00	0.00	0.00	44.62
p504	5615.00	11620.47	22410.13	1457.00	1764.65	1198.42	86.40	0.00	0.00	0.00	44.62
p505	5615.00	10951.10	20046.38	1355.10	1600.00	863.57	86.40	0.00	0.00	0.00	44.62
p506	5615.00	10951.10	18203.34	1073.00	1129.55	743.44	86.40	0.00	0.00	0.00	40.74
p507	5615.00	10951.10	16029.46	973.57	499.79	698.44	0.00	0.00	0.00	0.00	40.74
p508	5615.00	10951.10	14410.24	428.65	452.00	628.44	0.00	0.00	0.00	0.00	34.92
p509	5615.00	10951.10	13647.87	482.65	452.00	645.94	0.00	0.00	0.00	0.00	34.92
p510	5615.00	10951.10	13988.39	482.65	452.00	668.44	86.40	0.00	0.00	0.00	34.92
p511	5615.00	10951.10	15713.90	712.53	452.00	760.94	86.40	0.00	0.00	0.00	38.80
p512	5615.00	10951.10	16693.06	1457.00	468.50	905.14	86.40	0.00	0.00	0.00	40.74
p513	5615.00	10951.10	17796.90	1457.00	559.68	986.82	86.40	0.00	0.00	0.00	40.74
p514	5615.00	10951.10	20152.01	1054.54	878.95	1100.47	86.40	0.00	0.00	0.00	38.80
p515	5615.00	11385.50	21407.62	1408.10	1682.33	2163.48	86.40	0.00	0.00	0.00	44.62
p516	5615.00	12250.77	23135.39	1354.10	1844.17	3587.87	86.40	0.00	0.00	0.00	44.62
p517	5615.00	12754.92	25280.09	1457.00	2190.09	4205.40	217.00	0.00	0.00	0.00	55.32
p518	5615.00	13141.97	27242.05	1457.00	2633.24	4522.90	86.40	0.00	565.47	38.25	44.62
p519	5615.00	13260.10	28431.60	1511.00	2768.00	4868.19	318.75	0.00	1710.46	38.25	58.20
p520	5615.00	13260.10	28431.60	1739.10	2768.00	4978.00	554.25	0.00	2588.20	81.33	65.96
p521	5615.00	13260.10	28431.60	1841.00	2768.00	4978.00	570.00	0.00	2913.47	78.52	62.86
p522	5615.00	13260.10	28431.60	1841.00	2768.00	4978.00	570.00	0.00	2184.42	79.39	66.74
p523	5615.00	13260.10	28414.63	1841.00	2768.00	4751.65	396.63	0.00	769.74	0.00	61.10
p524	5615.00	13260.10	26744.10	1738.10	2768.00	4199.69	96.00	0.00	0.00	0.00	45.62
p525	5615.00	13075.19	25089.90	1355.10	2633.24	3610.05	96.00	0.00	0.00	0.00	44.62
p526	5615.00	12691.39	24715.09	1073.00	2190.09	3801.48	0.00	0.00	0.00	0.00	65.96
p527	5615.00	12171.19	22489.27	1073.00	1764.65	3294.74	0.00	0.00	0.00	0.00	44.62
p528	5615.00	11211.62	20778.73	1073.00	1600.00	2065.58	0.00	0.00	0.00	0.00	44.62
p529	5615.00	10663.80	18985.64	1073.00	1247.26	1141.06	0.00	0.00	0.00	0.00	40.74
p530	5615.00	10663.80	16472.00	1073.00	753.53	976.34	0.00	0.00	0.00	0.00	40.74
p531	5615.00	10663.80	14134.76	973.57	802.75	931.34	0.00	0.00	0.00	0.00	40.74
p532	5615.0	10663.8	13298.5	422.65	452.00	886.34	0.00	0.00	0.00	0.00	34.92

	0	0	6								
p533	5615.00	10663.80	12682.49	422.65	452.00	859.23	0.00	0.00	0.00	0.00	34.92
p534	5615.00	10663.80	12673.86	422.65	452.00	859.23	0.00	0.00	0.00	0.00	34.92
p535	5615.00	10663.80	13257.55	428.65	452.00	735.58	0.00	0.00	0.00	0.00	34.92
p536	5615.00	10663.80	14072.33	428.65	452.00	698.44	0.00	0.00	0.00	0.00	34.92
p537	5615.00	10768.08	15340.61	794.19	733.46	808.44	0.00	0.00	0.00	0.00	38.80
p538	5615.00	10872.36	18096.89	1073.00	1454.51	941.23	0.00	0.00	0.00	0.00	42.68
p539	5615.00	10976.64	21311.03	1180.00	1682.33	1439.12	0.00	0.00	0.00	0.00	44.62
p540	5615.00	11628.75	23346.88	1636.19	1663.62	2241.73	86.40	0.00	0.00	0.00	40.74
p541	5615.00	12066.91	25119.53	1841.00	2031.05	3658.01	86.40	0.00	0.00	0.00	48.50
p542	5615.00	12369.19	26839.45	1841.00	2200.00	4184.23	198.79	0.00	331.22	0.00	50.44
p543	5615.00	12752.99	27695.63	1841.00	2200.00	4672.87	523.39	0.00	991.59	0.00	58.20
p544	5615.00	13075.19	27712.60	1841.00	2200.00	4911.24	570.00	0.00	1425.86	51.00	58.20
p545	5615.00	13260.10	27712.60	1841.00	2200.00	4978.00	570.00	0.00	2110.44	51.00	58.20
p548	5615.00	13260.10	26691.32	1739.10	2200.00	4587.37	182.40	0.00	75.89	0.00	47.06
p549	5615.00	13142.37	25593.79	1457.00	2200.00	3803.84	0.00	0.00	0.00	0.00	44.95
p550	5615.00	12711.48	24753.60	1457.00	2031.05	3795.78	0.00	0.00	0.00	0.00	64.02
p551	5615.00	12061.38	23182.33	1354.10	1764.65	2936.54	0.00	0.00	0.00	0.00	44.62
p552	5615.00	10960.87	22261.88	1073.00	1600.00	1562.62	0.00	0.00	0.00	0.00	44.62
p553	5615.00	10104.40	20801.57	1069.58	878.95	851.91	0.00	0.00	0.00	0.00	38.80
p554	5615.00	10104.40	18015.43	1073.00	861.23	806.91	0.00	0.00	0.00	0.00	40.74
p555	5615.00	10104.40	15944.12	1073.00	937.35	721.91	0.00	0.00	0.00	0.00	40.74
p556	5615.00	10104.40	14727.72	763.02	452.00	676.91	0.00	0.00	0.00	0.00	38.80
p557	5615.00	10104.40	13770.02	428.65	452.00	653.44	0.00	0.00	0.00	0.00	34.92
p558	5615.00	10104.40	13346.05	428.65	452.00	628.44	0.00	0.00	0.00	0.00	34.92
p559	5615.00	10104.40	13661.77	428.65	452.00	650.94	0.00	0.00	0.00	0.00	34.92
p560	5615.00	10154.21	13146.10	647.36	452.00	760.94	0.00	0.00	0.00	0.00	38.80
p561	5615.00	10204.02	14415.21	502.65	452.00	856.32	0.00	0.00	0.00	0.00	36.86
p562	5615.00	10304.63	17089.92	1047.57	1087.88	1031.75	86.40	0.00	0.00	0.00	40.74
p563	5615.00	10628.21	19862.26	1126.00	1600.00	1671.80	86.40	0.00	0.00	0.00	44.62
p564	5615.00	11464.88	22846.40	1408.10	1761.85	2539.78	86.40	0.00	0.00	0.00	44.62
p565	5615.00	12053.88	25387.19	1739.10	1923.69	3520.37	86.40	0.00	0.00	0.00	44.62
p566	5615.00	12564.16	26647.95	1841.00	2464.29	4600.61	405.15	0.00	192.54	0.00	56.26
p567	5615.00	12899.76	27866.93	1841.00	2768.00	4950.50	824.25	0.00	615.54	12.75	58.20

p568	5615.00	13164.78	28431.60	1841.00	2768.00	4978.00	840.00	0.00	1467.90	51.00	58.20
p569	5615.00	13380.05	28431.60	1841.00	2768.00	4978.00	840.00	0.00	2561.32	51.00	58.20
p570	5615.00	13620.40	28431.60	1841.00	2768.00	4978.00	840.00	0.00	2367.28	51.00	60.70
p571	5615.00	13816.30	28431.60	1841.00	2768.00	4978.00	840.00	0.00	1471.27	51.00	63.70
p572	5615.00	13833.50	28132.60	1841.00	2768.00	4900.73	518.20	0.00	349.33	0.00	55.32
p573	5615.00	13583.24	27695.63	1841.00	2633.24	4664.18	97.87	0.00	97.96	0.00	54.65
p574	5615.00	13120.59	27409.60	1738.10	2359.04	4264.80	222.75	0.00	0.00	0.00	62.35
p575	5615.00	12375.99	25645.46	1355.10	2031.05	3833.90	0.00	0.00	0.00	0.00	44.62
p576	5615.00	11872.05	22894.86	1073.00	1764.65	2354.08	0.00	0.00	0.00	0.00	44.97
p577	5615.00	11560.10	20115.85	1073.00	1482.36	1196.97	0.00	0.00	0.00	0.00	43.34
p578	5615.00	11560.10	17413.72	581.76	761.31	1097.25	0.00	0.00	0.00	0.00	39.40
p579	5615.00	11560.10	15733.57	428.65	452.00	825.39	0.00	0.00	0.00	0.00	35.46
p580	5615.00	11560.10	14772.68	428.65	452.00	678.28	0.00	0.00	0.00	0.00	35.46
p581	5615.00	11560.10	14338.28	428.65	452.00	650.78	0.00	0.00	0.00	0.00	35.46
p582	5615.00	11560.10	14709.35	428.65	452.00	678.28	0.00	0.00	0.00	0.00	35.46
p583	5615.00	11611.64	16891.41	528.08	452.00	869.44	0.00	0.00	0.00	0.00	35.46
p584	5615.00	11663.19	17539.05	1073.00	1173.05	1636.63	0.00	0.00	0.00	0.00	45.31
p585	5615.00	11868.33	18902.53	1073.00	621.28	973.37	0.00	0.00	0.00	0.00	41.37
p586	5615.00	12495.86	20888.30	1126.00	1493.64	1204.45	0.00	0.00	0.00	0.00	41.37
p587	5615.00	13212.74	21991.61	1408.10	1923.69	2678.01	86.40	0.00	0.00	0.00	45.31
p588	5615.00	13747.87	24196.36	1739.10	2464.29	3763.50	86.40	0.00	25.11	0.00	45.31
p589	5615.00	14287.06	26488.64	1841.00	2768.00	4669.81	222.75	0.00	371.97	0.00	62.07
p590	5615.00	14684.91	28545.82	1841.00	2768.00	5462.98	452.40	0.00	954.52	0.00	59.10
p591	5615.00	15292.00	29570.40	1841.00	2768.00	5724.88	824.25	0.00	1262.46	25.50	59.10
p592	5615.00	15767.35	29570.40	1841.00	2768.00	5779.60	840.00	0.00	1839.44	51.00	59.10
p593	5615.00	15990.10	29570.40	1841.00	2768.00	5834.32	840.00	0.00	2235.12	78.37	91.87
p594	5615.00	15990.10	29570.40	1841.00	2768.00	5862.03	840.00	0.00	2161.17	51.00	79.91
p595	5615.00	15990.10	29570.40	1841.00	2768.00	5864.49	840.00	0.00	1225.20	51.00	63.36
p596	5615.00	15990.10	29014.60	1841.00	2768.00	5725.79	588.58	0.00	238.90	0.00	55.41
p597	5615.00	15990.10	27712.60	1841.00	2768.00	5299.66	270.00	0.00	188.18	0.00	59.43
p598	5615.00	15866.85	27639.82	1739.10	2464.29	4689.12	257.86	0.00	105.41	0.00	55.16
p599	5615.00	15528.08	24823.12	1438.64	1923.69	3854.20	143.55	0.00	0.00	0.00	55.16
p600	5615.00	15189.30	22331.98	1294.10	1443.89	2051.65	86.40	0.00	0.00	0.00	41.63
p601	5615.0	14450.1	19924.3	1013.0	1028.6	1053.7	86.40	0.00	0.00	0.00	41.90

	0	0	9	0	5	7					
p602	5615.00	14450.10	16910.92	931.93	500.41	914.05	86.40	0.00	0.00	0.00	41.90
p603	5615.00	14450.10	15209.16	422.65	452.00	749.33	0.00	0.00	0.00	0.00	35.91
p604	5615.00	14450.10	14328.31	422.65	452.00	704.33	0.00	0.00	0.00	0.00	35.91
p605	5615.00	14450.10	14353.52	428.65	452.00	634.33	0.00	0.00	0.00	0.00	35.91
p606	5615.00	14450.10	14604.85	528.08	452.00	661.83	86.40	0.00	0.00	0.00	35.91
p607	5615.00	14450.10	15545.76	1073.00	1173.05	939.58	86.40	0.00	0.00	0.00	45.89
p608	5615.00	14450.10	16787.40	1073.00	1600.00	1726.01	86.40	0.00	0.00	0.00	45.89
p609	5615.00	14450.10	18138.90	1037.60	878.95	982.98	86.40	0.00	0.00	0.00	39.90
p610	5615.00	14450.10	20390.39	1073.00	1679.52	1162.75	86.40	0.00	0.00	0.00	45.89
p611	5615.00	14450.10	22485.78	1073.00	1841.37	2448.20	86.40	0.00	0.00	0.00	45.89
p612	5615.00	15189.30	24963.67	1180.00	2197.89	3291.07	86.40	0.00	0.00	0.00	45.89
p613	5615.00	15528.08	27077.39	1636.19	2599.05	4050.99	131.46	0.00	0.00	0.00	55.86
p614	5615.00	15866.85	28564.13	1841.00	2768.00	4461.15	316.05	0.00	317.60	25.50	52.07
p615	5615.00	15990.10	29008.60	1841.00	2768.00	4800.60	824.25	0.00	1247.16	65.25	63.84
p616	5615.00	15990.10	29008.60	1841.00	2768.00	4895.89	840.00	0.00	2283.87	77.55	63.84
p617	5615.00	15990.10	29008.60	1841.00	2768.00	4886.60	840.00	0.00	2833.06	116.50	85.39
p618	5615.00	15990.10	29008.60	1841.00	2768.00	4831.88	840.00	0.00	1757.83	85.46	63.84
p619	5615.00	15990.10	28872.60	1841.00	2768.00	4772.17	777.00	0.00	287.24	0.00	56.73
p620	5615.00	15900.00	28132.60	1739.10	2633.24	4030.65	268.80	0.00	28.50	0.00	45.89
p621	5615.00	15483.12	27546.79	1457.00	2359.04	4046.05	172.80	0.00	28.50	0.00	45.89
p622	5615.00	14926.77	27008.63	1457.00	2200.00	3911.06	492.75	0.00	75.00	0.00	63.98
p623	5615.00	13922.97	25034.90	1354.10	2031.05	3343.60	0.00	0.00	0.00	0.00	47.88
p624	5615.00	13411.50	22397.42	1073.00	1685.05	1801.85	0.00	0.00	0.00	0.00	44.06
p625	5615.00	12965.10	19924.61	1026.06	799.35	936.30	0.00	0.00	0.00	0.00	40.20
p626	5615.00	12965.10	17453.76	589.92	452.00	891.30	0.00	0.00	0.00	0.00	40.20
p627	5615.00	12965.10	15757.10	686.78	452.00	846.30	0.00	0.00	0.00	0.00	40.20
p628	5615.00	12965.10	15165.31	428.65	452.00	792.10	0.00	0.00	0.00	0.00	36.18
p629	5615.00	12965.10	14373.04	428.65	452.00	773.19	0.00	0.00	0.00	0.00	36.18
p630	5615.00	12965.10	14780.01	428.65	452.00	649.54	0.00	0.00	0.00	0.00	36.18
p631	5615.00	12965.10	17052.11	528.08	452.00	694.54	0.00	0.00	0.00	0.00	36.18
p632	5615.00	13039.50	18016.68	1073.00	1173.05	917.22	0.00	0.00	0.00	0.00	46.23
p633	5615.00	13113.90	19197.63	962.50	551.60	784.54	0.00	0.00	0.00	0.00	40.20
p634	5615.00	13188.30	21700.53	1073.00	1434.50	843.47	0.00	0.00	0.00	0.00	44.22

p635	5615.00	13571.97	23238.53	1127.00	2190.09	1593.42	0.00	0.00	0.00	0.00	46.23
p636	5615.00	13838.37	25463.76	1408.10	2633.24	2709.87	0.00	0.00	35.95	0.00	46.23
p637	5615.00	14104.77	26971.85	1738.10	2768.00	3680.66	182.40	0.00	75.89	0.00	55.26
p638	5615.00	14438.70	27871.83	1841.00	2768.00	4161.10	507.00	0.00	411.17	38.25	60.30
p639	5615.00	14640.90	28431.60	1841.00	2768.00	4435.67	570.00	0.00	1111.09	133.52	64.32
p640	5615.00	14720.10	28431.60	1841.00	2768.00	4527.16	570.00	0.00	1057.86	38.25	60.30
p641	5615.00	14714.17	28431.60	1841.00	2768.00	4581.88	570.00	0.00	1076.52	38.25	60.30
p642	5615.00	14675.65	28431.60	1841.00	2768.00	4636.60	570.00	0.00	1076.38	102.67	115.08
p643	5615.00	14532.78	28132.60	1841.00	2633.24	4478.76	507.00	0.00	818.37	37.61	69.14
p644	5615.00	14389.90	27712.60	1841.00	2359.04	4033.63	86.40	0.00	156.59	0.00	47.84
p645	5615.00	14006.30	27429.11	1738.10	2200.00	3122.12	86.40	0.00	28.50	0.00	46.23
p646	5615.00	13677.75	26316.79	1457.00	2031.05	3355.68	222.75	0.00	75.00	0.00	72.60
p647	5615.00	13291.65	24109.42	1355.10	1764.65	2140.61	0.00	0.00	0.00	0.00	46.23
p648	5615.00	12667.05	21108.69	1073.00	1542.50	1095.70	0.00	0.00	0.00	0.00	42.42
p649	5615.00	12355.10	17835.30	1007.62	827.45	930.98	0.00	0.00	0.00	0.00	42.63
p650	5615.00	12355.10	15551.44	456.71	452.00	885.98	0.00	0.00	0.00	0.00	38.57
p651	5615.00	12355.10	13295.79	422.65	452.00	840.98	0.00	0.00	0.00	0.00	36.54
p652	5615.00	12355.10	12003.18	422.65	452.00	653.44	0.00	0.00	0.00	0.00	36.54
p653	5615.00	12355.10	11680.01	428.65	452.00	605.94	0.00	0.00	0.00	0.00	36.54
p654	5615.00	12355.10	12626.04	428.65	452.00	628.44	0.00	0.00	0.00	0.00	36.54
p655	5615.00	12355.10	13991.76	973.57	965.84	656.04	0.00	0.00	0.00	0.00	42.63
p656	5615.00	12355.10	15556.23	1073.00	1482.63	1201.45	0.00	0.00	0.00	0.00	46.69
p657	5615.00	12355.10	17438.36	528.08	761.58	865.76	0.00	0.00	0.00	0.00	38.57
p658	5615.00	12355.10	19447.95	1073.00	1071.48	965.48	0.00	0.00	0.00	0.00	42.63
p659	5615.00	12789.50	21041.33	1126.00	1764.65	1568.48	0.00	0.00	0.00	0.00	46.69
p660	5615.00	13297.35	22535.61	1408.10	2031.05	2443.84	86.40	0.00	0.00	0.00	46.69
p661	5615.00	13683.45	24419.70	1739.10	2200.00	3696.19	86.40	0.00	0.00	0.00	46.69
p662	5615.00	13952.45	26283.62	1841.00	2200.00	4164.80	318.75	0.00	167.43	0.00	62.93
p663	5615.00	14085.10	27546.79	1841.00	2200.00	4451.14	554.25	0.00	805.76	51.00	60.90
p664	5615.00	14085.10	27712.60	1841.00	2200.00	4533.00	570.00	0.00	1739.10	51.00	60.90
p665	5615.00	14085.10	27712.60	1841.00	2200.00	4533.00	570.00	0.00	1984.53	51.76	64.96
p666	5615.00	14085.10	27712.60	1841.00	2200.00	4533.00	541.21	0.00	1504.02	38.25	62.55
p667	5615.00	14085.10	27695.63	1739.10	2200.00	4496.32	216.61	0.00	307.29	0.00	52.95
p668	5615.0	13874.1	27281.1	1354.1	2200.0	3784.9	96.00	0.00	102.98	0.00	46.94

	0	7	0	0	0	0					
p669	5615.00	13479.97	26833.60	1073.00	2200.00	3735.53	0.00	0.00	0.00	0.00	46.69
p670	5615.00	13085.77	26226.79	1073.00	2031.05	3827.19	0.00	0.00	0.00	0.00	85.07
p671	5615.00	12330.10	23556.60	1073.00	1764.65	3133.22	0.00	0.00	0.00	0.00	46.69
p672	5615.00	12330.10	20078.10	1073.00	1600.00	1999.03	0.00	0.00	0.00	0.00	46.58
p673	5615.00	12330.10	17889.59	1062.88	878.95	1091.96	0.00	0.00	0.00	0.00	40.40
p674	5615.00	12330.10	15833.47	1030.97	452.00	939.82	0.00	0.00	0.00	0.00	40.40
p675	5615.00	12330.10	15172.11	535.64	452.00	894.82	0.00	0.00	0.00	0.00	40.40
p676	5615.00	12330.10	13881.23	422.65	452.00	703.67	0.00	0.00	0.00	0.00	36.36
p677	5615.00	12330.10	13542.30	422.65	452.00	633.67	0.00	0.00	0.00	0.00	36.36
p678	5615.00	12330.10	14315.92	428.65	452.00	650.94	0.00	0.00	0.00	0.00	36.36
p679	5615.00	12330.10	15466.75	973.57	998.49	678.44	0.00	0.00	0.00	0.00	42.42
p680	5615.00	12330.10	16593.61	1073.00	1600.00	1253.30	0.00	0.00	0.00	0.00	46.46
p681	5615.00	12330.10	17939.00	620.41	878.95	980.58	0.00	0.00	0.00	0.00	40.40
p682	5615.00	12404.50	19919.59	1073.00	901.73	1080.30	0.00	0.00	0.00	0.00	42.42
p683	5615.00	12478.90	21334.90	1180.00	1533.97	1514.79	0.00	0.00	0.00	0.00	42.42
p684	5615.00	12553.30	22572.60	1636.19	1764.65	3009.70	0.00	0.00	0.00	0.00	50.50
p685	5615.00	12627.70	24510.23	1841.00	2031.05	3908.13	86.40	0.00	0.00	0.00	46.46
p686	5615.00	12702.10	26314.13	1841.00	2200.00	4181.50	191.80	0.00	443.80	0.00	56.56
p687	5615.00	12776.50	27113.79	1841.00	2200.00	4281.51	270.00	0.00	1228.91	25.50	60.60
p688	5615.00	12978.70	27656.79	1841.00	2200.00	4226.79	270.00	0.00	1449.19	25.50	60.60
p689	5615.00	13180.90	27712.60	1841.00	2200.00	4186.88	270.00	0.00	1877.86	12.75	94.54
p690	5615.00	13260.10	27712.60	1841.00	2200.00	3962.66	248.88	0.00	1572.86	0.00	60.60
p691	5615.00	13260.10	27695.63	1739.10	2031.05	3572.38	112.53	0.00	222.79	0.00	53.52
p692	5615.00	13127.45	26158.29	1457.00	1764.65	3034.40	86.40	0.00	0.00	0.00	46.46
p693	5615.00	12875.65	25315.79	1457.00	1600.00	2666.44	86.40	0.00	0.00	0.00	50.96
p694	5615.00	12435.19	24450.13	1457.00	1600.00	2602.79	86.40	0.00	0.00	0.00	53.25
p695	5615.00	11793.24	23363.70	1457.00	1591.39	1579.39	86.40	0.00	0.00	0.00	42.42
p696	5615.00	11238.84	22090.18	1354.10	980.99	758.23	86.40	0.00	0.00	0.00	42.42
p697	5615.00	10925.10	20273.23	736.33	452.00	713.23	86.40	0.00	0.00	0.00	40.40
p698	5615.00	10925.10	17495.44	1073.00	832.43	668.23	0.00	0.00	0.00	0.00	42.42
p699	5615.00	10925.10	15618.63	1073.00	830.08	628.44	0.00	0.00	0.00	0.00	42.42
p700	5615.00	10925.10	15306.91	636.82	452.00	605.94	0.00	0.00	0.00	0.00	40.40
p701	5615.00	10925.10	14065.22	481.65	452.00	583.44	86.40	0.00	0.00	0.00	36.36

p702	5615.00	10925.10	13372.94	481.65	452.00	605.94	86.40	0.00	0.00	0.00	36.36
p703	5615.00	10925.10	14254.15	481.65	452.00	653.44	86.40	0.00	0.00	0.00	36.36
p704	5615.00	10925.10	15283.90	587.96	452.00	680.94	86.40	0.00	0.00	0.00	40.40
p705	5615.00	10925.10	16346.86	788.05	452.00	725.94	86.40	0.00	0.00	0.00	40.40
p706	5615.00	10925.10	18781.82	1457.00	567.25	806.65	86.40	0.00	0.00	0.00	42.42
p707	5615.00	11347.50	21426.55	1322.97	961.28	923.84	86.40	0.00	0.00	0.00	40.40
p708	5615.00	11859.24	22687.07	1636.19	1764.65	2018.12	86.40	0.00	0.00	0.00	46.46
p709	5615.00	12189.24	24722.03	1457.00	2031.05	3025.83	86.40	0.00	0.00	0.00	46.46
p710	5615.00	12382.84	26241.99	1457.00	2200.00	3856.70	127.39	0.00	213.06	12.75	52.52
p711	5615.00	12435.10	27169.80	1457.00	2200.00	4020.40	263.74	0.00	688.95	51.00	60.60
p712	5615.00	12435.10	27712.60	1510.00	2200.00	4080.50	270.00	0.00	1258.83	51.00	60.60
p713	5615.00	12435.10	27712.60	1738.10	2200.00	4103.00	270.00	0.00	1723.40	62.36	64.64
p714	5615.00	12435.10	27712.60	1841.00	2200.00	4080.50	242.09	0.00	1436.32	38.25	61.41
p715	5615.00	12435.10	27695.63	1841.00	2200.00	4053.00	233.62	0.00	357.55	12.75	65.45
p716	5615.00	12435.10	26219.28	1841.00	2200.00	3693.98	97.27	0.00	0.00	0.00	56.15
p717	5615.00	12356.30	24915.40	1841.00	2200.00	3008.99	86.40	0.00	0.00	0.00	46.79
p718	5615.00	12121.47	23510.90	1739.10	2200.00	2493.50	0.00	0.00	0.00	0.00	46.46
p719	5615.00	11740.32	21848.71	1354.10	2031.05	1728.21	0.00	0.00	0.00	0.00	46.46
p720	5615.00	10997.67	19972.24	1073.00	1764.65	955.52	0.00	0.00	0.00	0.00	46.46
p721	5615.00	10572.50	17992.48	1073.00	1004.52	704.30	0.00	0.00	0.00	0.00	42.42
p722	5615.00	10126.10	17051.18	528.08	452.00	634.30	0.00	0.00	0.00	0.00	36.36
p723	5615.00	10126.10	14649.01	1073.00	646.58	589.30	0.00	0.00	0.00	0.00	42.42
p724	5615.00	10126.10	13692.82	686.64	452.00	511.80	0.00	0.00	0.00	0.00	40.40
p725	5615.00	10126.10	12384.08	428.65	452.00	489.30	0.00	0.00	0.00	0.00	36.36
p726	5615.00	10126.10	11529.80	428.65	452.00	481.12	0.00	0.00	0.00	0.00	36.36
p727	5615.00	10126.10	11986.40	428.65	452.00	503.62	0.00	0.00	0.00	0.00	36.36
p728	5615.00	10126.10	12712.74	428.65	452.00	526.12	0.00	0.00	0.00	0.00	36.36
p729	5615.00	10126.10	13744.18	528.08	452.00	573.62	0.00	0.00	0.00	0.00	36.36
p730	5615.00	10126.10	16268.51	1073.00	1173.05	602.09	0.00	0.00	0.00	0.00	46.46
p731	5615.00	10126.10	19243.58	1073.00	717.30	687.55	0.00	0.00	0.00	0.00	42.42
p732	5615.00	10349.07	21489.81	1073.00	1273.44	723.98	0.00	0.00	0.00	0.00	42.42
p733	5615.00	10901.52	23065.00	1073.00	1600.00	1608.94	0.00	0.00	0.00	0.00	46.46
p734	5615.00	11209.77	24729.82	1073.00	1682.33	2014.97	86.40	0.00	0.00	0.00	46.46
p735	5615.0	11450.9	25580.6	1073.0	1764.6	2606.8	86.40	0.00	0.00	0.00	50.50

	0	0	0	0	5	2					
p736	5615.00	11530.10	26276.79	1073.00	2031.05	2629.32	163.39	0.00	347.34	38.25	56.56
p738	5615.00	11530.10	26332.60	1073.00	2200.00	2437.32	223.95	0.00	947.99	56.66	67.06
p739	5615.00	11530.10	26332.60	1073.00	2200.00	2051.87	87.60	0.00	192.54	12.75	58.73
p740	5615.00	11468.50	25061.09	1073.00	2200.00	1625.22	86.40	0.00	0.00	0.00	47.46
p741	5615.00	11270.50	24028.09	1054.64	2200.00	1515.52	86.40	0.00	0.00	0.00	48.46
p742	5615.00	11072.50	22961.34	1013.00	2031.05	1518.49	86.40	0.00	0.00	0.00	46.46
p743	5615.00	10650.10	20722.38	1013.00	1764.65	1131.91	0.00	0.00	0.00	0.00	46.46
p744	5615.00	10650.10	17389.10	1013.00	1600.00	772.60	0.00	0.00	0.00	0.00	23.23

APPENDIX B: OUTPUTS OF MODEL UC_RMIP

Type	NUC	CLLIG	CCGT90	CCLE90	GSSUP	GSREH	SCGT90	GSNONR	SCLE90	DSL	EP_RMIP
p1	5615.00	15355.10	15462.25	1013.03	291.70	104.86	0.00	0.00	0.00	0.00	39.14
p2	5615.00	15355.10	13123.32	503.75	260.00	123.83	0.00	0.00	0.00	0.00	36.56
p3	5615.00	15355.10	11624.85	422.68	260.00	123.86	0.00	0.00	0.00	0.00	33.93
p4	5615.00	15355.10	10431.39	422.68	260.00	123.86	0.00	0.00	0.00	0.00	33.93
p5	5615.00	15355.10	10457.43	422.76	260.00	123.86	0.00	0.00	0.00	0.00	33.93
p6	5615.00	15355.10	11194.82	422.76	260.00	123.86	0.74	0.00	0.00	0.00	33.93
p7	5615.00	15355.10	12703.51	503.85	260.00	123.86	0.74	0.00	0.00	0.00	36.37
p8	5615.00	15355.10	13548.16	1014.12	291.30	123.86	0.74	0.00	0.00	0.00	39.59
p9	5615.00	15355.10	14867.94	1014.37	260.00	146.36	0.74	0.00	0.00	0.00	38.67
p10	5615.00	15355.10	16868.10	816.16	260.00	168.86	0.74	0.00	0.00	0.00	37.70
p11	5615.00	15355.10	18226.92	1014.59	621.50	212.26	0.74	0.00	0.00	0.00	40.02
p12	5615.00	14988.34	20050.41	1013.63	978.23	305.90	0.74	0.00	0.00	0.00	39.88
p13	5615.00	14672.91	21693.25	1014.50	1174.85	920.68	0.74	0.00	0.00	0.00	44.36
p14	5615.00	14669.89	22773.30	1015.61	1508.46	1421.29	1.47	0.00	0.00	0.00	44.62
p15	5615.00	14669.89	24013.88	1017.21	1889.14	1816.49	2.21	0.00	25.28	0.00	48.24
p16	5615.00	14669.89	24443.77	1018.66	2003.43	2121.09	7.64	0.00	41.52	0.00	64.60
p17	5615.00	14669.89	24448.44	1019.11	2085.71	2314.94	2.95	0.00	25.28	0.00	59.87
p18	5615.00	14192.74	24451.08	1019.11	2117.71	2378.99	2.95	0.00	25.28	0.00	48.68
p19	5615.00	13417.51	24451.08	1018.93	2200.00	2379.16	2.95	0.00	25.28	0.00	53.77
p20	5615.00	12049.19	24317.10	1019.15	2200.00	2051.78	2.95	0.00	0.00	0.00	45.88
p21	5615.00	10842.57	23334.42	1019.36	2200.00	1897.49	2.95	0.00	0.00	0.00	44.82
p22	5615.00	10551.43	23334.42	1019.58	2200.00	2189.01	2.95	0.00	0.00	0.00	49.52
p23	5615.00	9615.33	22844.07	1019.76	1985.97	2063.77	2.95	0.00	0.00	0.00	45.85
p24	5615.00	8515.97	21720.62	1019.76	1683.71	1295.63	2.95	0.00	0.00	0.00	43.36
p25	5615.00	8271.39	19383.96	1019.76	1600.00	479.95	2.95	0.00	0.00	0.00	41.16
p26	5615.00	8261.52	17299.71	1019.76	878.95	458.39	2.95	0.00	0.00	0.00	39.46
p27	5615.00	8261.52	15971.33	1019.76	773.24	436.84	2.95	0.00	0.00	0.00	39.59
p28	5615.00	8250.49	15195.32	925.71	452.00	414.34	2.95	0.00	0.00	0.00	37.70
p29	5615.00	8240.92	15013.43	423.83	452.00	414.34	5.89	0.00	0.00	0.00	34.70
p30	5615.00	8240.92	14728.21	424.25	452.00	414.34	8.84	0.00	0.00	0.00	33.93
p31	5615.00	8240.92	15096.97	425.05	452.00	427.37	11.78	0.00	0.00	0.00	33.93
p32	5615.00	8240.92	15373.02	555.89	452.00	449.87	11.78	0.00	0.00	0.00	37.70
p33	5615.00	8240.92	16364.45	1036.68	452.00	448.18	11.78	0.00	0.00	0.00	39.23
p34	5615.00	8240.92	18760.47	1040.05	1013.13	507.54	11.78	0.00	0.00	0.00	39.59
p35	5615.00	8240.92	20889.74	1036.68	1600.00	598.58	11.78	0.00	0.00	0.00	42.01
p36	5615.00	8329.32	22110.16	1037.05	1650.38	1058.06	11.78	0.00	0.00	0.00	43.36
p37	5615.00	8444.87	22515.29	1033.58	1700.75	2203.55	11.78	0.00	0.00	0.00	44.36
p38	5615.00	8476.16	23280.75	1047.69	1999.10	2694.06	20.62	0.00	0.00	0.00	47.19
p39	5615.00	8496.76	24400.90	1073.97	2031.05	2900.65	32.40	0.00	0.00	0.00	44.19
p40	5615.00	8517.36	25196.75	1096.90	2200.00	3143.51	44.18	0.00	47.37	0.00	47.19

p41	5615.00	8528.39	25920.84	1114.85	2200.00	3297.24	141.02	0.00	200.63	0.00	61.67
p42	5615.00	8528.39	26046.73	1121.00	2200.00	3350.62	147.28	0.00	439.27	0.00	81.44
p43	5615.00	8528.39	26048.40	1121.00	2200.00	3328.12	147.28	0.00	338.79	0.00	61.60
p44	5615.00	8528.39	25636.26	1121.00	2200.00	3109.99	47.13	0.00	58.94	0.00	48.31
p45	5615.00	8528.39	24622.12	1104.35	2200.00	2457.63	26.51	0.00	0.00	0.00	43.69
p46	5615.00	8528.39	24214.83	1104.35	2200.00	2715.20	17.62	0.00	0.00	0.00	47.69
p47	5615.00	8528.39	22527.66	1064.75	1933.60	2415.51	17.62	0.00	0.00	0.00	44.96
p48	5615.00	8386.62	20691.02	1064.75	1663.90	1275.27	17.62	0.00	0.00	0.00	41.75
p49	5615.00	8082.67	18849.81	1064.75	1153.07	628.56	17.62	0.00	0.00	0.00	39.59
p50	5615.00	7921.74	17403.05	1064.75	452.00	588.69	17.62	0.00	0.00	0.00	39.52
p51	5615.00	7829.97	15620.45	1064.75	452.00	544.26	17.62	0.00	0.00	0.00	38.91
p52	5615.00	7683.88	14863.94	916.51	452.00	521.76	15.64	0.00	0.00	0.00	37.70
p53	5615.00	7629.06	14687.45	436.40	452.00	499.26	17.62	0.00	0.00	0.00	33.93
p54	5615.00	7629.06	14745.67	443.46	452.00	499.73	19.61	0.00	0.00	0.00	33.93
p55	5615.00	7629.06	14952.91	513.54	452.00	522.23	21.60	0.00	0.00	0.00	37.70
p56	5615.00	7629.06	14781.51	450.90	452.00	544.73	21.60	0.00	0.00	0.00	33.93
p57	5615.00	7629.06	15942.87	1138.93	452.00	519.37	21.60	0.00	0.00	0.00	38.20
p58	5615.00	7773.71	18269.77	1216.63	1173.05	565.45	21.60	0.00	0.00	0.00	40.08
p59	5615.00	8231.84	20790.69	1217.00	1631.95	670.13	21.60	0.00	0.00	0.00	41.86
p60	5615.00	8994.01	22284.91	1138.50	1714.27	1808.07	21.60	0.00	0.00	0.00	43.68
p61	5615.00	9764.56	23096.22	1201.06	1933.60	2747.05	21.60	0.00	0.00	0.00	45.07
p62	5615.00	10232.41	24301.74	1318.38	2200.00	3041.88	41.21	0.00	0.00	0.00	48.28
p63	5615.00	10528.46	25783.20	1521.25	2200.00	3351.34	62.82	0.00	0.00	0.00	48.15
p64	5615.00	10765.55	26571.75	1707.00	2200.00	3648.31	127.45	0.00	210.58	19.46	50.98
p65	5615.00	10827.24	26819.88	1799.69	2200.00	3860.45	265.81	0.00	712.96	43.89	67.75
p66	5615.00	10827.24	26918.66	1841.00	2200.00	3905.98	270.04	0.00	1191.31	43.89	79.88
p67	5615.00	10827.24	26918.66	1841.00	2200.00	3906.59	270.04	0.00	990.82	43.89	67.01
p68	5615.00	10827.24	26918.66	1841.00	2200.00	3760.69	114.05	0.00	135.94	0.00	49.67
p69	5615.00	10827.24	25637.40	1409.00	2200.00	3540.43	45.20	0.00	17.16	0.00	48.03
p70	5615.00	10827.24	25299.33	1217.00	2200.00	3314.67	39.02	0.00	0.00	0.00	48.33
p71	5615.00	10827.24	23140.94	1129.40	1933.60	2716.78	21.61	0.00	0.00	0.00	45.39
p72	5615.00	10827.24	20746.22	1124.00	1663.90	1320.24	21.61	0.00	0.00	0.00	41.90
p73	5615.00	10798.87	18070.36	1028.00	878.95	758.45	21.61	0.00	0.00	0.00	40.53
p74	5615.00	10659.65	15789.81	946.93	452.00	714.65	21.61	0.00	0.00	0.00	39.20
p75	5615.00	10545.75	14601.48	437.53	452.00	669.65	21.61	0.00	0.00	0.00	36.62
p76	5615.00	10539.77	13171.95	450.90	452.00	642.15	21.62	0.00	0.00	0.00	34.83
p77	5615.00	10539.77	12488.00	450.90	452.00	642.97	21.63	0.00	0.00	0.00	34.83
p78	5615.00	10539.77	13147.57	450.90	452.00	665.47	21.64	0.00	0.00	0.00	34.83
p79	5615.00	10539.77	14728.63	804.20	452.00	644.05	21.64	0.00	0.00	0.00	38.70
p80	5615.00	10581.21	15403.76	1220.00	905.12	655.83	21.64	0.00	0.00	0.00	40.64
p81	5615.00	10784.56	17497.43	1206.50	878.95	701.82	21.64	0.00	0.00	0.00	40.48
p82	5615.00	11128.99	20179.56	1138.88	1631.95	871.19	21.64	0.00	0.00	0.00	40.86
p83	5615.00	11477.58	22439.51	1167.25	1714.27	1903.54	21.64	0.00	0.00	0.00	44.51
p84	5615.00	11826.18	24352.80	1374.25	1933.60	3256.89	43.24	0.00	0.00	0.00	46.02

p85	5615.00	12174.78	26668.67	1579.75	2200.00	3743.66	67.85	0.00	0.00	0.00	51.66
p86	5615.00	12733.38	27951.51	1758.38	2200.00	4284.16	152.23	0.00	192.54	0.00	51.15
p87	5615.00	13090.29	28386.77	1841.00	2200.00	4638.28	403.65	0.00	807.66	51.00	63.41
p88	5615.00	13100.12	28433.11	1841.00	2200.00	4776.93	439.31	0.00	2095.35	51.00	68.40
p89	5615.00	13100.12	28433.35	1841.00	2200.00	4815.96	439.34	0.00	2710.34	51.00	88.56
p90	5615.00	13100.12	28433.40	1841.00	2200.00	4815.96	439.34	0.00	2060.49	51.00	70.69
p91	5615.00	13100.12	28433.40	1841.00	2200.00	4730.62	400.27	0.00	1103.75	40.35	64.68
p92	5615.00	13100.12	27729.01	1770.42	2200.00	4274.29	125.93	0.00	122.54	0.00	49.93
p93	5615.00	13100.12	26368.03	1467.21	2200.00	3698.41	66.73	0.00	0.00	0.00	49.59
p94	5615.00	13100.12	25946.34	1307.25	2200.00	3309.41	60.56	0.00	0.00	0.00	49.59
p95	5615.00	12590.31	23633.13	1129.40	1933.60	2899.87	21.78	0.00	0.00	0.00	46.34
p96	5615.00	11462.89	21694.71	1124.00	1663.90	1599.75	21.78	0.00	0.00	0.00	43.71
p97	5615.00	10748.27	18962.11	1028.00	1600.00	829.91	21.78	0.00	0.00	0.00	40.99
p98	5615.00	10658.21	16019.31	960.00	1071.40	784.91	21.78	0.00	0.00	0.00	40.64
p99	5615.00	10658.21	14752.79	450.59	452.00	739.91	21.60	0.00	0.00	0.00	36.77
p100	5615.00	10658.21	13103.98	450.90	452.00	712.41	21.78	0.00	0.00	0.00	34.83
p101	5615.00	10658.21	12581.49	450.90	452.00	689.91	21.96	0.00	0.00	0.00	34.83
p102	5615.00	10658.21	13139.59	450.90	452.00	675.87	22.14	0.00	0.00	0.00	34.83
p103	5615.00	10658.21	14459.14	531.97	452.00	683.68	22.14	0.00	0.00	0.00	37.00
p104	5615.00	10670.70	14946.14	1220.00	898.56	680.28	22.14	0.00	0.00	0.00	40.64
p105	5615.00	10704.32	16924.21	1220.00	887.65	712.49	22.14	0.00	0.00	0.00	40.64
p106	5615.00	10758.10	20188.35	1123.88	1621.48	857.19	22.14	0.00	0.00	0.00	41.37
p107	5615.00	11324.01	22199.67	1152.25	1693.33	1921.13	22.14	0.00	0.00	0.00	44.51
p108	5615.00	12527.70	23993.76	1359.25	1921.08	3001.86	43.74	0.00	0.00	0.00	44.70
p109	5615.00	13332.99	26003.16	1566.25	2277.47	3823.77	97.90	0.00	0.00	0.00	49.59
p110	5615.00	13586.76	27833.84	1758.38	2633.24	4427.23	232.70	0.00	177.79	0.00	57.00
p111	5615.00	13724.10	28456.95	1841.00	2768.00	4813.35	561.43	0.00	647.02	23.38	59.07
p112	5615.00	13724.10	28462.86	1841.00	2768.00	4983.41	562.95	0.00	1685.58	51.00	67.09
p113	5615.00	13724.10	28468.77	1841.00	2768.00	5033.00	563.40	0.00	2649.66	51.00	76.08
p114	5615.00	13724.10	28470.16	1841.00	2768.00	5033.00	563.40	0.00	2805.38	51.00	84.88
p115	5615.00	13724.10	28470.16	1841.00	2768.00	4968.38	551.87	0.00	1770.47	51.00	67.15
p116	5615.00	13724.10	28140.17	1841.00	2768.00	4724.54	293.54	0.00	177.35	0.00	56.10
p117	5615.00	13724.10	26525.25	1552.20	2493.80	3981.01	66.38	0.00	17.16	0.00	49.38
p118	5615.00	13645.30	25970.20	1552.20	2252.41	3431.92	60.20	0.00	0.00	0.00	49.93
p119	5615.00	12950.59	23392.92	1225.40	1933.60	2941.78	23.75	0.00	0.00	0.00	46.34
p120	5615.00	11821.70	21513.16	1220.00	1663.90	1621.33	23.75	0.00	0.00	0.00	43.72
p121	5615.00	11236.49	18857.66	1028.00	1173.05	833.00	23.75	0.00	0.00	0.00	41.16
p122	5615.00	11163.75	16599.62	1028.00	452.00	788.00	23.75	0.00	0.00	0.00	41.16
p123	5615.00	11163.75	15102.49	505.22	452.00	743.00	23.75	0.00	0.00	0.00	37.38
p124	5615.00	11163.75	13602.05	450.90	452.00	715.50	25.89	0.00	0.00	0.00	35.28
p125	5615.00	11163.75	13116.57	450.90	452.00	693.00	28.04	0.00	0.00	0.00	35.28
p126	5615.00	11163.75	13278.86	450.90	452.00	715.50	30.19	0.00	0.00	0.00	35.28
p127	5615.00	11163.75	14930.08	531.97	452.00	692.10	30.19	0.00	0.00	0.00	38.09
p128	5615.00	11163.75	15469.55	1220.00	505.95	665.06	30.19	0.00	0.00	0.00	41.16

p129	5615.00	11171.12	17081.31	1220.00	841.14	716.59	30.19	0.00	0.00	0.00	41.16
p130	5615.00	11178.48	20020.36	1206.50	1488.61	884.07	30.19	0.00	0.00	0.00	41.16
p131	5615.00	11701.19	21996.68	1056.25	1650.38	1808.87	30.19	0.00	0.00	0.00	45.08
p132	5615.00	12909.68	23788.11	1263.25	1786.02	2902.26	51.79	0.00	0.00	0.00	45.08
p133	5615.00	13682.11	25804.82	1470.25	2163.89	3888.81	79.83	0.00	0.00	0.00	50.06
p134	5615.00	13768.27	27804.27	1675.75	2633.24	4499.80	314.31	0.00	211.86	0.00	51.81
p135	5615.00	13816.12	28865.90	1841.00	2768.00	5012.20	890.34	0.00	977.43	51.00	65.67
p136	5615.00	13816.12	28960.76	1841.00	2768.00	5198.00	955.13	0.00	2526.26	51.00	72.07
p137	5615.00	13816.12	28983.02	1841.00	2768.00	5198.00	960.52	0.00	3134.97	51.00	88.76
p138	5615.00	13816.12	28983.02	1841.00	2768.00	5198.00	960.52	0.00	2979.94	51.00	73.60
p139	5615.00	13816.12	28983.02	1841.00	2768.00	5133.38	960.52	0.00	1831.05	51.00	67.64
p140	5615.00	13816.12	28573.04	1841.00	2768.00	4832.86	758.53	0.00	294.86	0.00	58.80
p141	5615.00	13816.12	27202.87	1575.58	2493.80	4077.86	64.38	0.00	0.00	0.00	50.11
p142	5615.00	13816.12	26496.03	1433.62	2252.41	3444.72	55.79	0.00	0.00	0.00	50.11
p143	5615.00	13367.56	23951.20	1163.60	2031.05	2983.08	50.00	0.00	0.00	0.00	48.39
p144	5615.00	12592.95	21164.11	1124.00	1700.75	1613.59	21.60	0.00	0.00	0.00	43.41
p145	5615.00	12168.31	18581.70	1028.00	1022.05	825.71	21.60	0.00	0.00	0.00	41.90
p146	5615.00	11949.68	16334.45	946.93	452.00	780.71	21.60	0.00	0.00	0.00	41.50
p147	5615.00	11813.37	14882.41	437.53	452.00	735.71	21.60	0.00	0.00	0.00	37.65
p148	5615.00	11813.37	13327.49	450.90	452.00	708.21	21.60	0.00	0.00	0.00	35.91
p149	5615.00	11813.37	12332.37	450.90	452.00	685.71	21.60	0.00	0.00	0.00	35.91
p150	5615.00	11813.37	13067.52	450.90	452.00	671.67	21.60	0.00	0.00	0.00	35.91
p151	5615.00	11813.37	14719.91	531.97	452.00	679.48	21.60	0.00	0.00	0.00	38.24
p152	5615.00	11813.37	15347.87	1220.00	609.10	667.49	21.60	0.00	0.00	0.00	41.90
p153	5615.00	11813.37	17118.60	1220.00	925.76	719.02	21.60	0.00	0.00	0.00	41.90
p154	5615.00	11942.65	20107.60	1123.88	1486.31	913.92	21.60	0.00	0.00	0.00	41.90
p155	5615.00	12738.94	22704.39	1152.25	1727.67	1883.26	21.60	0.00	0.00	0.00	45.89
p156	5615.00	13967.07	24311.42	1359.25	2013.72	3233.65	43.20	0.00	0.00	0.00	46.89
p157	5615.00	14794.93	26431.57	1566.25	2415.15	3868.04	95.18	0.00	0.00	0.00	50.33
p158	5615.00	15193.53	27939.39	1758.38	2702.15	4458.40	212.14	0.00	276.49	0.00	56.73
p159	5615.00	15346.76	28477.81	1841.00	2768.00	4830.53	515.27	0.00	846.23	51.00	69.34
p160	5615.00	15346.76	28490.09	1841.00	2768.00	4978.00	515.27	0.00	1753.74	51.00	68.59
p161	5615.00	15346.76	28492.98	1841.00	2768.00	4978.00	515.27	0.00	2051.65	51.00	87.66
p162	5615.00	15346.76	28492.98	1841.00	2768.00	4978.00	515.27	0.00	1811.90	51.00	70.34
p163	5615.00	15346.76	28492.98	1841.00	2768.00	4913.38	470.61	0.00	949.33	28.63	66.45
p164	5615.00	15346.76	28091.33	1841.00	2699.09	4592.06	162.12	0.00	152.83	0.00	54.49
p165	5615.00	15312.79	26921.42	1310.96	2398.09	3869.20	66.76	0.00	0.00	0.00	50.05
p166	5615.00	15202.63	26643.64	1310.96	2225.61	3421.36	60.59	0.00	0.00	0.00	51.42
p167	5615.00	14439.58	24089.83	1221.03	2031.05	2955.53	21.60	0.00	0.00	0.00	48.99
p168	5615.00	13241.09	21915.39	1162.57	1700.75	1628.23	21.60	0.00	0.00	0.00	44.56
p169	5615.00	12727.59	19529.05	1124.00	1238.50	840.34	21.60	0.00	0.00	0.00	41.37
p170	5615.00	12727.59	17297.04	1042.93	721.74	795.34	21.60	0.00	0.00	0.00	41.37
p171	5615.00	12727.59	16428.15	445.48	452.00	750.34	21.60	0.00	0.00	0.00	36.80
p172	5615.00	12727.59	15342.26	450.90	452.00	722.84	21.60	0.00	0.00	0.00	35.46

p173	5615.00	12727.59	15080.21	450.90	452.00	700.34	21.60	0.00	0.00	0.00	35.46
p174	5615.00	12727.59	15617.62	450.90	452.00	668.42	21.60	0.00	0.00	0.00	35.46
p175	5615.00	12727.59	16455.25	1138.93	664.98	649.17	21.60	0.00	0.00	0.00	41.37
p176	5615.00	12727.59	17074.88	1220.00	1081.38	687.64	21.60	0.00	0.00	0.00	41.37
p177	5615.00	12727.59	18829.42	1206.50	1446.35	744.94	21.60	0.00	0.00	0.00	41.37
p178	5615.00	12800.33	22052.10	1089.40	1631.95	1252.96	21.60	0.00	0.00	0.00	43.92
p179	5615.00	13469.22	24023.53	1224.68	1740.48	2660.70	40.09	0.00	0.00	0.00	46.70
p180	5615.00	14686.91	25212.64	1431.68	2039.32	3570.44	61.69	0.00	0.00	0.00	47.02
p181	5615.00	15308.12	26776.84	1637.18	2493.80	4162.48	223.44	0.00	63.48	0.00	49.67
p182	5615.00	15308.12	28414.57	1807.85	2768.00	4720.20	698.79	0.00	581.81	51.00	61.83
p183	5615.00	15308.12	28816.47	1841.00	2768.00	4918.82	826.93	0.00	1861.94	51.00	69.94
p184	5615.00	15308.12	28902.41	1841.00	2768.00	4978.00	826.93	0.00	2339.91	51.00	84.00
p185	5615.00	15308.12	28922.66	1841.00	2768.00	4978.00	826.93	0.00	2271.74	51.00	73.58
p186	5615.00	15308.12	28922.66	1841.00	2768.00	4978.00	826.93	0.00	1983.82	51.00	69.59
p187	5615.00	15308.12	28867.69	1841.00	2768.00	4915.16	769.02	0.00	855.31	5.22	63.81
p188	5615.00	14940.24	28093.26	1841.00	2633.24	4451.81	104.83	0.00	123.98	0.00	53.50
p189	5615.00	14184.61	27291.83	1310.96	2306.63	3572.28	66.76	0.00	0.00	0.00	46.24
p190	5615.00	13827.11	27205.89	1310.96	2200.00	3370.75	66.76	0.00	0.00	0.00	54.33
p191	5615.00	13598.94	24841.70	1265.00	2031.05	2953.68	60.59	0.00	0.00	0.00	49.02
p192	5615.00	12916.56	22768.14	1225.40	1700.75	2044.62	21.60	0.00	0.00	0.00	46.10
p193	5615.00	12412.07	20691.28	1124.00	1600.00	840.49	21.60	0.00	0.00	0.00	42.98
p194	5615.00	12376.57	18240.99	1124.00	1322.85	795.49	21.60	0.00	0.00	0.00	41.37
p195	5615.00	12376.57	17036.07	1124.00	1173.05	750.49	21.60	0.00	0.00	0.00	43.11
p196	5615.00	12376.57	16477.42	858.35	452.00	705.49	21.60	0.00	0.00	0.00	39.40
p197	5615.00	12376.57	16098.11	450.90	452.00	682.99	21.60	0.00	0.00	0.00	38.41
p198	5615.00	12376.57	15400.81	450.90	452.00	660.49	21.60	0.00	0.00	0.00	35.46
p199	5615.00	12376.57	15575.07	450.90	452.00	634.89	21.60	0.00	0.00	0.00	35.46
p200	5615.00	12376.57	14957.66	450.90	452.00	638.51	21.60	0.00	0.00	0.00	35.46
p201	5615.00	12376.57	16805.01	696.95	452.00	683.51	21.60	0.00	0.00	0.00	39.40
p202	5615.00	12376.57	19418.10	1221.50	1173.05	817.99	21.60	0.00	0.00	0.00	42.50
p203	5615.00	12376.57	21988.37	1071.25	1650.38	1499.66	21.60	0.00	0.00	0.00	45.05
p204	5615.00	12860.48	23800.83	1278.25	1732.70	2987.34	43.20	0.00	0.00	0.00	46.57
p205	5615.00	13485.91	25335.04	1483.75	2031.05	3591.56	64.80	0.00	0.00	0.00	48.41
p206	5615.00	13541.99	27169.94	1675.75	2200.00	4073.85	138.76	0.00	230.49	12.75	50.63
p207	5615.00	13541.99	28273.58	1841.00	2200.00	4534.95	386.39	0.00	706.77	38.25	71.19
p208	5615.00	13541.99	28273.75	1841.00	2200.00	4662.29	433.64	0.00	1057.09	51.00	64.48
p209	5615.00	13541.99	28273.79	1841.00	2200.00	4684.79	433.64	0.00	1310.92	51.00	70.28
p210	5615.00	13541.99	28273.79	1841.00	2200.00	4684.79	433.64	0.00	1387.91	51.00	82.44
p211	5615.00	13541.99	28273.67	1841.00	2200.00	4640.77	433.64	0.00	1112.95	51.00	68.20
p212	5615.00	13541.99	28014.19	1841.00	2200.00	4252.51	167.48	0.00	132.31	0.00	51.31
p213	5615.00	13541.99	26648.52	1310.96	2200.00	3789.22	67.87	0.00	17.16	0.00	50.29
p214	5615.00	13541.99	25756.59	1265.00	2200.00	3328.42	66.76	0.00	0.00	0.00	49.76
p215	5615.00	12892.09	24078.62	1265.00	2031.05	2858.34	33.01	0.00	0.00	0.00	48.59
p216	5615.00	11615.41	22765.60	1225.40	1700.75	2046.72	21.60	0.00	0.00	0.00	46.04

p217	5615.00	10752.23	21418.49	1220.00	1600.00	843.44	21.60	0.00	0.00	0.00	43.28
p218	5615.00	10578.06	18602.33	1220.00	1600.00	798.44	21.60	0.00	0.00	0.00	42.17
p219	5615.00	10552.44	16279.12	1220.00	1173.05	753.44	21.60	0.00	0.00	0.00	42.89
p220	5615.00	10552.44	15813.90	709.44	452.00	709.07	21.60	0.00	0.00	0.00	39.40
p221	5615.00	10552.44	15391.52	450.90	452.00	686.57	21.60	0.00	0.00	0.00	36.91
p222	5615.00	10552.44	14756.90	450.90	452.00	670.77	21.60	0.00	0.00	0.00	35.46
p223	5615.00	10552.44	14924.19	450.90	452.00	623.73	21.60	0.00	0.00	0.00	35.46
p224	5615.00	10552.44	14718.47	450.90	452.00	645.21	21.60	0.00	0.00	0.00	35.46
p225	5615.00	10552.44	16229.71	675.18	559.36	690.21	21.60	0.00	0.00	0.00	39.40
p226	5615.00	10552.44	19461.31	1221.50	1280.41	828.27	21.60	0.00	0.00	0.00	43.34
p227	5615.00	11044.38	22621.70	1071.25	1650.38	1372.51	21.60	0.00	0.00	0.00	44.85
p228	5615.00	12363.37	23932.89	1278.25	1732.70	2891.21	43.20	0.00	0.00	0.00	46.61
p229	5615.00	13421.02	25597.84	1483.75	2031.05	3651.68	64.80	0.00	0.00	0.00	48.18
p230	5615.00	13674.36	27404.78	1675.75	2200.00	4214.28	120.83	0.00	282.08	15.03	52.45
p231	5615.00	13702.12	28221.93	1841.00	2200.00	4608.85	330.34	0.00	1137.14	51.00	70.72
p232	5615.00	13702.12	28224.81	1841.00	2200.00	4710.71	377.59	0.00	2116.76	51.00	85.86
p233	5615.00	13702.12	28225.49	1841.00	2200.00	4726.51	377.59	0.00	1830.69	51.00	72.07
p234	5615.00	13702.12	28225.49	1841.00	2200.00	4726.51	377.59	0.00	1001.74	28.30	65.70
p235	5615.00	13702.12	28225.49	1841.00	2200.00	4639.55	257.18	0.00	404.11	0.00	61.44
p236	5615.00	13702.12	27637.65	1770.42	2200.00	4233.05	90.60	0.00	45.18	0.00	50.96
p237	5615.00	13702.12	25927.93	1240.38	2200.00	3651.73	56.18	0.00	0.00	0.00	49.71
p238	5615.00	13702.12	25545.79	1169.00	2200.00	3086.64	56.18	0.00	0.00	0.00	49.81
p239	5615.00	13569.47	23848.89	1129.40	1933.60	2178.91	21.60	0.00	0.00	0.00	46.97
p240	5615.00	13488.81	21820.21	1124.00	1663.90	929.49	21.60	0.00	0.00	0.00	44.00
p241	5615.00	13359.88	19315.26	1028.00	1561.23	830.55	21.60	0.00	0.00	0.00	42.00
p242	5615.00	13270.98	17683.48	1028.00	1173.05	785.55	21.60	0.00	0.00	0.00	42.01
p243	5615.00	13260.30	17098.55	960.30	452.00	740.55	21.60	0.00	0.00	0.00	40.82
p244	5615.00	13260.30	16281.34	450.90	452.00	713.05	21.60	0.00	0.00	0.00	36.00
p245	5615.00	13260.30	16029.36	450.90	452.00	690.55	21.60	0.00	0.00	0.00	36.00
p246	5615.00	13260.30	16639.35	450.90	452.00	669.56	21.60	0.00	0.00	0.00	36.00
p247	5615.00	13260.30	17023.11	1138.93	1173.05	661.50	21.60	0.00	0.00	0.00	42.44
p248	5615.00	13260.30	17676.66	1220.00	1542.71	667.35	21.60	0.00	0.00	0.00	42.00
p249	5615.00	13260.30	19625.50	1206.50	878.95	719.02	21.60	0.00	0.00	0.00	42.00
p250	5615.00	13348.30	21785.76	1138.88	1631.95	921.98	21.60	0.00	0.00	0.00	44.96
p251	5615.00	13657.47	23408.69	1167.25	1740.48	1890.61	21.60	0.00	0.00	0.00	46.00
p252	5615.00	14018.63	24638.40	1374.25	2039.32	2886.11	43.20	0.00	0.00	0.00	46.00
p253	5615.00	14247.14	26585.21	1579.75	2493.80	3998.62	186.26	0.00	15.33	0.00	50.72
p254	5615.00	14398.34	28231.54	1758.38	2768.00	4582.04	480.98	0.00	469.27	0.00	61.55
p255	5615.00	14409.91	28695.36	1841.00	2768.00	4856.30	649.56	0.00	1573.94	51.00	68.33
p256	5615.00	14409.91	28751.93	1841.00	2768.00	4978.34	649.56	0.00	3038.21	51.34	78.43
p257	5615.00	14409.91	28765.26	1841.00	2768.00	4978.34	649.56	0.00	3203.14	51.34	89.59
p258	5615.00	14409.91	28765.26	1841.00	2768.00	4978.34	644.00	0.00	1562.78	50.91	67.70
p259	5615.00	14409.91	28726.62	1841.00	2768.00	4801.82	473.19	0.00	297.49	0.00	60.43
p260	5615.00	14298.89	27846.38	1310.96	2633.24	4168.55	56.18	0.00	0.00	0.00	50.83

p261	5615.00	14196.40	26352.46	1169.00	2306.63	3637.29	56.18	0.00	0.00	0.00	50.25
p262	5615.00	14196.40	26067.71	1169.00	2200.00	3315.81	56.18	0.00	0.00	0.00	51.41
p263	5615.00	13614.60	23821.12	1129.40	1933.60	2920.92	21.60	0.00	0.00	0.00	47.51
p264	5615.00	12886.43	22064.98	1124.00	1663.90	1602.60	21.60	0.00	0.00	0.00	44.70
p265	5615.00	12718.02	19349.92	1028.00	1600.00	832.76	21.60	0.00	0.00	0.00	41.71
p266	5615.00	12718.02	17260.28	1028.00	1072.87	787.76	21.60	0.00	0.00	0.00	41.37
p267	5615.00	12718.02	16458.92	518.60	452.00	742.76	21.60	0.00	0.00	0.00	37.81
p268	5615.00	12718.02	15220.92	450.90	452.00	715.26	21.61	0.00	0.00	0.00	35.46
p269	5615.00	12718.02	14909.41	450.90	452.00	692.76	21.61	0.00	0.00	0.00	35.46
p270	5615.00	12718.02	15289.30	450.90	452.00	661.77	21.61	0.00	0.00	0.00	35.46
p271	5615.00	12718.02	16310.48	967.04	452.00	661.71	21.61	0.00	0.00	0.00	39.40
p272	5615.00	12718.02	17128.91	1220.00	1173.05	667.49	21.61	0.00	0.00	0.00	42.32
p273	5615.00	12718.02	18751.53	1206.50	906.73	719.02	21.61	0.00	0.00	0.00	41.37
p274	5615.00	12718.02	21150.09	1138.88	1631.95	924.05	21.61	0.00	0.00	0.00	43.46
p275	5615.00	13198.82	23335.76	1167.25	1740.48	2257.28	40.08	0.00	0.00	0.00	45.31
p276	5615.00	13949.04	24797.48	1374.25	2039.32	3507.02	61.69	0.00	0.00	0.00	46.94
p277	5615.00	14196.40	26675.73	1579.75	2493.80	4091.83	156.31	0.00	63.50	0.00	50.44
p278	5615.00	14196.40	28057.99	1758.38	2768.00	4643.24	470.64	0.00	480.09	12.75	61.34
p279	5615.00	14196.40	28432.74	1841.00	2768.00	4857.79	559.61	0.00	1641.04	51.00	67.41
p280	5615.00	14196.40	28432.98	1841.00	2768.00	4980.04	559.61	0.00	2762.81	51.00	87.42
p281	5615.00	14196.40	28433.04	1841.00	2768.00	4980.04	559.61	0.00	2570.31	51.00	73.90
p282	5615.00	14196.40	28433.04	1841.00	2768.00	4980.04	559.61	0.00	1927.36	51.00	68.67
p283	5615.00	14196.40	28432.87	1841.00	2768.00	4860.99	503.67	0.00	532.70	0.00	61.25
p284	5615.00	13946.53	27727.87	1770.42	2633.24	4246.80	78.11	0.00	32.09	0.00	51.15
p285	5615.00	13585.96	26039.40	1240.38	2306.63	3591.91	58.49	0.00	17.16	0.00	49.71
p286	5615.00	13339.10	25787.93	1240.38	2200.00	3092.08	58.49	0.00	0.00	0.00	50.38
p287	5615.00	12787.56	23474.93	1129.40	1933.60	2758.03	21.64	0.00	0.00	0.00	46.97
p288	5615.00	11397.45	22160.27	1124.00	1663.90	1587.53	21.64	0.00	0.00	0.00	44.36
p289	5615.00	10556.05	19426.04	1124.00	1600.00	817.69	21.64	0.00	0.00	0.00	41.08
p290	5615.00	10556.05	17706.63	1028.00	887.89	772.69	21.64	0.00	0.00	0.00	40.95
p291	5615.00	10556.05	16753.05	708.17	452.00	727.69	21.60	0.00	0.00	0.00	39.00
p292	5615.00	10556.05	15834.91	437.53	452.00	700.19	21.64	0.00	0.00	0.00	35.10
p293	5615.00	10556.05	15056.66	450.90	452.00	677.69	21.68	0.00	0.00	0.00	35.10
p294	5615.00	10556.05	15479.87	450.90	452.00	700.19	21.72	0.00	0.00	0.00	35.10
p295	5615.00	10556.05	16510.11	1138.93	452.00	682.69	21.72	0.00	0.00	0.00	40.18
p296	5615.00	10556.05	17098.60	1220.00	1173.05	688.94	21.72	0.00	0.00	0.00	41.23
p297	5615.00	10556.05	18434.40	1206.50	1074.66	710.62	21.72	0.00	0.00	0.00	40.95
p298	5615.00	10556.05	20918.18	1221.50	1604.43	844.03	21.72	0.00	0.00	0.00	43.12
p299	5615.00	10995.84	22736.53	1153.88	1659.24	1799.68	21.72	0.00	0.00	0.00	44.85
p300	5615.00	12309.78	23795.44	1182.25	1804.21	2892.89	43.32	0.00	0.00	0.00	45.55
p301	5615.00	13260.10	25369.42	1387.75	2177.65	3673.26	72.02	0.00	0.00	0.00	48.98
p302	5615.00	13260.10	27184.19	1579.75	2583.56	4211.47	152.92	0.00	78.68	0.00	50.81
p303	5615.00	13260.10	28343.16	1758.38	2768.00	4711.91	430.88	0.00	497.18	51.00	60.90
p304	5615.00	13260.10	28435.27	1841.00	2768.00	4921.53	478.48	0.00	1747.74	51.00	68.08

p305	5615.00	13260.10	28436.10	1841.00	2768.00	4984.11	478.58	0.00	2629.53	51.00	86.36
p306	5615.00	13260.10	28436.29	1841.00	2768.00	4984.11	478.58	0.00	2469.37	51.00	73.30
p307	5615.00	13260.10	28436.29	1841.00	2768.00	4919.49	478.58	0.00	1706.54	51.00	67.43
p308	5615.00	13260.10	28110.76	1841.00	2768.00	4699.74	244.38	0.00	239.51	0.00	57.09
p309	5615.00	13260.10	26376.63	1391.50	2543.48	4049.49	66.68	0.00	17.16	0.00	49.89
p310	5615.00	13069.90	25826.33	1230.29	2271.73	3296.16	60.50	0.00	0.00	0.00	49.64
p311	5615.00	12765.64	23352.08	1190.69	1933.60	2179.88	22.09	0.00	0.00	0.00	46.61
p312	5615.00	11594.12	20770.43	1185.29	1663.90	919.65	22.09	0.00	0.00	0.00	42.52
p313	5615.00	10725.94	18047.82	1062.71	878.95	819.93	22.09	0.00	0.00	0.00	40.35
p314	5615.00	10725.94	15256.35	946.93	452.00	774.93	22.09	0.00	0.00	0.00	39.26
p315	5615.00	10725.94	13977.07	424.15	452.00	729.93	21.60	0.00	0.00	0.00	36.71
p316	5615.00	10725.94	12594.53	446.02	452.00	702.43	22.09	0.00	0.00	0.00	34.65
p317	5615.00	10725.94	11780.41	450.90	452.00	679.93	22.58	0.00	0.00	0.00	34.65
p318	5615.00	10725.94	12058.92	450.90	452.00	702.43	23.06	0.00	0.00	0.00	34.65
p319	5615.00	10725.94	13950.06	531.97	452.00	681.01	23.06	0.00	0.00	0.00	37.40
p320	5615.00	10725.94	14620.74	1220.00	1168.48	675.55	23.06	0.00	0.00	0.00	40.43
p321	5615.00	10725.94	16662.03	1220.00	452.00	712.49	23.06	0.00	0.00	0.00	40.27
p322	5615.00	10725.94	19958.39	1206.50	878.95	863.40	23.06	0.00	0.00	0.00	40.17
p323	5615.00	11016.72	21752.34	1086.08	1650.38	1725.12	23.06	0.00	0.00	0.00	44.28
p324	5615.00	12263.72	23508.98	1228.54	1742.13	2959.65	44.66	0.00	0.00	0.00	44.28
p325	5615.00	13260.10	25413.81	1435.54	2049.91	3773.72	94.74	0.00	0.00	0.00	48.04
p326	5615.00	13260.10	27618.00	1641.04	2267.34	4384.28	273.27	0.00	211.86	0.00	52.47
p327	5615.00	13260.10	28452.95	1811.17	2267.34	4813.29	709.28	0.00	803.72	51.00	64.64
p328	5615.00	13260.10	28472.80	1841.00	2267.34	4973.40	713.44	0.00	1973.39	51.00	66.82
p329	5615.00	13260.10	28480.71	1841.00	2267.34	5014.67	714.66	0.00	2812.07	51.00	75.58
p330	5615.00	13260.10	28482.53	1841.00	2267.34	5014.67	714.66	0.00	3026.80	51.00	85.78
p331	5615.00	13260.10	28478.90	1841.00	2267.34	4929.33	695.76	0.00	1381.36	49.08	64.38
p332	5615.00	13260.10	27702.92	1685.75	2267.34	4407.48	215.65	0.00	143.99	0.00	49.68
p333	5615.00	13260.10	26061.68	1155.71	2218.85	3831.59	60.18	0.00	0.00	0.00	48.95
p334	5615.00	13017.30	25403.82	1155.71	2200.00	3184.19	59.53	0.00	0.00	0.00	48.95
p335	5615.00	12253.89	23275.52	1116.11	1933.60	2302.56	27.46	0.00	0.00	0.00	46.16
p336	5615.00	10840.12	21036.26	1110.71	1663.90	1034.39	27.46	0.00	0.00	0.00	42.10
p337	5615.00	10042.26	18505.92	1062.71	878.95	833.70	27.46	0.00	0.00	0.00	39.82
p338	5615.00	10042.26	15663.00	946.93	692.88	788.70	27.46	0.00	0.00	0.00	39.90
p339	5615.00	10042.26	14514.41	434.51	452.00	743.70	22.90	0.00	0.00	0.00	35.25
p340	5615.00	10042.26	13476.30	446.02	452.00	716.20	28.76	0.00	0.00	0.00	34.20
p341	5615.00	10042.26	13011.34	450.90	452.00	693.70	34.61	0.00	0.00	0.00	34.20
p342	5615.00	10042.26	13411.83	450.90	452.00	679.66	40.47	0.00	0.00	0.00	34.20
p343	5615.00	10042.26	14939.19	806.07	452.00	687.47	40.47	0.00	0.00	0.00	38.00
p344	5615.00	10042.26	15655.02	1220.00	1164.69	674.55	40.47	0.00	0.00	0.00	39.90
p345	5615.00	10042.26	17965.69	1206.50	878.95	719.02	40.47	0.00	0.00	0.00	39.77
p346	5615.00	10042.26	21137.59	1157.28	1631.95	1017.77	40.47	0.00	0.00	0.00	42.63
p347	5615.00	10772.79	22586.92	1175.66	1714.27	2402.37	40.47	0.00	0.00	0.00	44.77
p348	5615.00	12373.63	24048.84	1318.13	1986.92	3134.04	62.07	0.00	0.00	0.00	43.70

p349	5615.00	13260.10	26117.60	1523.63	2332.84	4009.78	104.09	0.00	0.00	0.00	49.08
p350	5615.00	13260.10	28137.82	1705.26	2633.24	4601.20	397.99	0.00	122.32	0.00	54.87
p351	5615.00	13260.10	28951.39	1811.17	2768.00	5007.02	1036.95	0.00	650.85	38.25	58.41
p352	5615.00	13260.10	29088.63	1841.00	2768.00	5187.25	1090.15	0.00	2161.29	51.00	66.00
p353	5615.00	13260.10	29209.09	1841.00	2768.00	5198.00	1104.84	0.00	3500.31	51.00	79.42
p354	5615.00	13260.10	29236.63	1841.00	2768.00	5198.00	1104.84	0.00	3659.75	51.00	89.64
p355	5615.00	13260.10	29162.59	1841.00	2768.00	5155.88	1104.84	0.00	1944.57	51.00	65.97
p356	5615.00	13260.10	28560.81	1841.00	2768.00	4785.50	754.46	0.00	157.75	0.00	54.90
p357	5615.00	13073.22	27614.95	1642.90	2493.80	4014.13	84.58	0.00	17.16	0.00	49.10
p358	5615.00	12710.56	26383.56	1492.95	2252.41	3475.33	65.71	0.00	0.00	0.00	49.03
p359	5615.00	12027.64	24130.75	1222.93	2019.88	2973.89	21.60	0.00	0.00	0.00	46.16
p360	5615.00	11128.54	22430.44	1183.33	1696.53	1768.94	21.60	0.00	0.00	0.00	43.70
p361	5615.00	10725.94	20462.17	1146.67	1595.23	877.49	21.60	0.00	0.00	0.00	39.98
p362	5615.00	10725.94	18373.05	1146.67	874.18	832.49	21.60	0.00	0.00	0.00	39.82
p363	5615.00	10725.94	17158.23	1151.82	856.27	787.49	21.60	0.00	0.00	0.00	39.90
p364	5615.00	10725.94	17090.67	1188.49	735.80	742.49	21.60	0.00	0.00	0.00	39.90
p365	5615.00	10725.94	16792.02	1014.63	452.00	719.99	21.60	0.00	0.00	0.00	38.00
p366	5615.00	10725.94	16203.05	450.90	452.00	675.53	21.60	0.00	0.00	0.00	35.03
p367	5615.00	10725.94	14729.37	450.90	452.00	629.95	21.60	0.00	0.00	0.00	34.20
p368	5615.00	10725.94	14553.63	450.90	452.00	668.42	21.60	0.00	0.00	0.00	34.20
p369	5615.00	10725.94	17264.87	531.97	492.30	723.17	21.60	0.00	0.00	0.00	36.50
p370	5615.00	10725.94	20363.48	1087.76	1245.30	950.04	21.60	0.00	0.00	0.00	43.30
p371	5615.00	11255.04	23237.69	1226.58	1714.27	2054.71	21.60	0.00	0.00	0.00	43.70
p372	5615.00	12232.77	24918.95	1433.58	1933.60	3494.67	61.76	0.00	0.00	0.00	46.16
p373	5615.00	12659.08	26678.69	1639.08	2200.00	4117.82	123.04	0.00	0.00	0.00	48.28
p374	5615.00	12659.08	28086.38	1809.49	2200.00	4678.26	267.80	0.00	711.38	51.00	57.66
p375	5615.00	12659.08	28086.38	1841.00	2200.00	4918.82	502.24	0.00	2520.88	51.00	70.59
p376	5615.00	12659.08	28086.38	1841.00	2200.00	4978.00	502.24	0.00	3356.03	51.00	91.05
p377	5615.00	12659.08	28086.38	1841.00	2200.00	4978.00	502.24	0.00	2622.50	80.05	71.76
p378	5615.00	12659.08	28086.38	1841.00	2200.00	4892.66	414.40	0.00	883.58	12.75	60.75
p379	5615.00	12659.08	27764.71	1589.67	2200.00	4524.63	126.92	0.00	17.16	0.00	49.03
p380	5615.00	12659.08	26862.38	1382.28	2200.00	4065.98	72.55	0.00	0.00	0.00	49.03
p381	5615.00	12532.76	25435.81	1088.93	2200.00	3532.37	56.47	0.00	0.00	0.00	48.50
p382	5615.00	12302.04	25295.51	1088.93	2200.00	3112.63	45.59	0.00	0.00	0.00	48.50
p383	5615.00	11700.82	24439.97	1088.93	2200.00	2751.72	39.41	0.00	0.00	0.00	48.39
p384	5615.00	10602.38	22893.43	1049.33	1933.60	2408.78	19.07	0.00	0.00	0.00	45.25
p385	5615.00	9913.95	21419.63	1043.93	1663.90	1313.36	19.07	0.00	0.00	0.00	42.33
p386	5615.00	9858.26	19473.00	1043.93	1600.00	700.70	19.07	0.00	0.00	0.00	40.74
p387	5615.00	9858.26	17549.34	1043.93	1400.49	659.28	19.07	0.00	0.00	0.00	42.07
p388	5615.00	9858.26	16620.93	505.22	679.44	614.28	19.07	0.00	0.00	0.00	37.73
p389	5615.00	9858.26	15426.87	426.37	452.00	591.78	19.07	0.00	0.00	0.00	34.20
p390	5615.00	9858.26	15790.75	428.59	452.00	569.28	19.07	0.00	0.00	0.00	34.20
p391	5615.00	9858.26	16051.51	430.81	452.00	567.63	19.07	0.00	0.00	0.00	34.20
p392	5615.00	9858.26	16309.27	631.61	452.00	590.13	19.07	0.00	0.00	0.00	38.00

p393	5615.00	9858.26	16971.43	821.90	778.97	576.97	19.07	0.00	0.00	0.00	38.00
p394	5615.00	9858.26	18809.63	1062.29	1500.02	620.34	19.07	0.00	0.00	0.00	41.80
p395	5615.00	9858.26	21568.43	1077.29	1631.95	706.95	19.07	0.00	0.00	0.00	43.60
p396	5615.00	10425.16	22980.83	1092.29	1714.27	1619.67	19.07	0.00	0.00	0.00	43.70
p397	5615.00	11089.50	23746.06	1079.87	1933.60	2634.30	20.89	0.00	0.00	0.00	44.70
p398	5615.00	11148.10	24866.64	1111.52	2200.00	2967.83	39.96	0.00	0.00	0.00	48.75
p399	5615.00	11148.10	25557.39	1159.31	2200.00	3261.94	59.04	0.00	0.00	0.00	47.45
p400	5615.00	11148.10	25961.61	1207.11	2200.00	3497.87	76.29	0.00	0.00	0.00	47.58
p401	5615.00	11148.10	26450.70	1250.46	2200.00	3676.15	107.56	0.00	247.33	12.59	58.30
p402	5615.00	11148.10	26537.60	1264.17	2200.00	3716.45	238.42	0.00	544.19	12.59	82.43
p403	5615.00	11148.10	26537.60	1264.17	2200.00	3721.55	212.64	0.00	480.58	12.59	65.03
p404	5615.00	11148.10	26095.47	1264.17	2200.00	3586.44	55.40	0.00	163.78	0.00	49.03
p405	5615.00	11148.10	25009.46	1264.17	2200.00	3450.62	55.40	0.00	0.00	0.00	47.72
p406	5615.00	11148.10	24565.78	1264.17	2200.00	3094.94	44.82	0.00	0.00	0.00	47.55
p407	5615.00	10884.79	23081.81	1224.57	1933.60	2661.92	21.60	0.00	0.00	0.00	45.45
p408	5615.00	10419.47	21575.15	1124.83	1663.90	1403.67	21.60	0.00	0.00	0.00	42.13
p409	5615.00	10096.20	19626.09	1124.00	1600.00	781.22	21.60	0.00	0.00	0.00	41.01
p410	5615.00	9983.57	17903.42	1124.00	1097.10	736.24	21.60	0.00	0.00	0.00	39.69
p411	5615.00	9983.57	17684.52	874.23	452.00	691.24	21.60	0.00	0.00	0.00	37.80
p412	5615.00	9983.57	17368.23	450.90	452.00	663.74	21.60	0.00	0.00	0.00	36.50
p413	5615.00	9983.57	16649.03	450.90	452.00	672.45	21.60	0.00	0.00	0.00	34.02
p414	5615.00	9983.57	16991.13	450.90	452.00	648.71	21.60	0.00	0.00	0.00	34.02
p415	5615.00	9983.57	17309.37	978.96	878.95	669.05	21.60	0.00	0.00	0.00	37.80
p416	5615.00	9983.57	18480.30	1220.00	1600.00	825.63	21.60	0.00	0.00	0.00	43.47
p417	5615.00	9987.60	20052.46	1206.50	1631.95	791.51	21.60	0.00	0.00	0.00	40.13
p418	5615.00	10214.75	22314.23	1056.96	1714.27	1253.95	21.60	0.00	0.00	0.00	43.47
p419	5615.00	11017.27	23853.75	1262.42	1933.60	2366.48	43.20	0.00	0.00	0.00	43.47
p420	5615.00	11932.05	25210.77	1469.42	2200.00	3479.00	64.80	0.00	0.00	0.00	49.23
p421	5615.00	12384.53	26418.11	1674.92	2200.00	4020.81	138.76	0.00	192.54	0.00	46.73
p422	5615.00	12508.82	27712.60	1840.29	2200.00	4561.23	386.39	0.00	453.54	0.00	67.13
p423	5615.00	12508.82	27712.60	1841.00	2200.00	4675.71	433.64	0.00	574.31	12.75	56.95
p424	5615.00	12508.82	27712.60	1841.00	2200.00	4727.92	433.64	0.00	1073.67	51.00	65.74
p425	5615.00	12508.82	27712.60	1841.00	2200.00	4727.97	433.64	0.00	1759.36	51.00	80.85
p426	5615.00	12508.82	27712.60	1841.00	2200.00	4727.97	433.64	0.00	1723.65	55.17	70.77
p427	5615.00	12508.82	27686.50	1841.00	2200.00	4642.38	236.11	0.00	430.13	0.00	58.22
p428	5615.00	12508.82	25773.50	1310.96	2200.00	4024.83	56.18	0.00	33.13	0.00	48.27
p429	5615.00	12508.82	25266.93	1169.00	2200.00	3275.32	56.18	0.00	0.00	0.00	43.80
p430	5615.00	12508.82	25266.93	1169.00	2200.00	3208.90	56.18	0.00	0.00	0.00	52.89
p431	5615.00	12380.69	23424.76	1129.40	1933.60	2756.29	21.60	0.00	0.00	0.00	45.53
p432	5615.00	11692.41	21929.50	1124.00	1663.90	1549.35	21.60	0.00	0.00	0.00	43.37
p433	5615.00	11161.74	19638.84	1124.00	1600.00	773.75	21.60	0.00	0.00	0.00	41.59
p434	5615.00	11161.74	17730.94	1028.00	1060.34	728.76	21.60	0.00	0.00	0.00	40.32
p435	5615.00	11149.06	16241.22	505.22	452.00	683.76	21.60	0.00	0.00	0.00	37.43
p436	5615.00	11141.35	14497.23	437.53	452.00	656.26	21.60	0.00	0.00	0.00	34.56

p437	5615.00	11141.35	13017.02	450.90	452.00	633.76	21.60	0.00	0.00	0.00	34.56
p438	5615.00	11141.35	13998.36	450.90	452.00	611.26	21.60	0.00	0.00	0.00	34.56
p439	5615.00	11141.35	16515.34	531.97	589.29	633.76	21.60	0.00	0.00	0.00	38.40
p440	5615.00	11141.35	16955.27	1220.00	1310.34	609.82	21.60	0.00	0.00	0.00	42.24
p441	5615.00	11141.35	17810.45	1220.00	1179.94	639.43	21.60	0.00	0.00	0.00	40.32
p442	5615.00	11149.06	19965.13	1206.50	1600.00	741.44	21.60	0.00	0.00	0.00	40.63
p443	5615.00	11288.68	21825.12	1221.50	1650.38	1148.85	21.60	0.00	0.00	0.00	44.10
p444	5615.00	11967.88	23102.02	1071.25	1732.70	2509.54	21.60	0.00	0.00	0.00	44.22
p445	5615.00	12557.31	24135.52	1278.25	2031.05	3210.13	43.20	0.00	0.00	0.00	49.24
p446	5615.00	12577.70	25755.20	1483.75	2200.00	3608.41	64.80	0.00	0.00	0.00	48.46
p447	5615.00	12598.09	26799.31	1675.75	2200.00	4021.77	86.40	0.00	275.58	35.92	47.12
p448	5615.00	12610.77	27577.98	1841.00	2200.00	4326.79	222.75	0.00	1055.36	51.00	70.73
p449	5615.00	12610.77	27712.60	1841.00	2200.00	4371.29	270.00	0.00	1756.36	51.00	72.91
p450	5615.00	12610.77	27712.60	1841.00	2200.00	4371.31	270.00	0.00	1857.62	51.00	79.38
p451	5615.00	12610.77	27712.60	1841.00	2200.00	4348.81	222.75	0.00	592.13	33.53	63.37
p452	5615.00	12610.77	26393.93	1457.00	2200.00	3938.94	43.20	0.00	60.83	0.00	48.73
p453	5615.00	12610.77	24943.11	1265.00	2200.00	3504.62	43.20	0.00	0.00	0.00	47.24
p454	5615.00	12414.87	24450.75	1169.00	2200.00	3056.06	43.20	0.00	0.00	0.00	48.86
p455	5615.00	11631.92	22951.66	1129.40	1933.60	2167.06	21.60	0.00	0.00	0.00	45.68
p456	5615.00	10783.71	21298.27	1124.00	1663.90	953.12	21.60	0.00	0.00	0.00	42.87
p457	5615.00	10328.70	18513.15	1124.00	1600.00	761.70	21.60	0.00	0.00	0.00	41.83
p458	5615.00	10114.70	17006.49	1028.00	878.95	717.18	21.60	0.00	0.00	0.00	40.03
p459	5615.00	10094.54	15735.75	946.93	452.00	672.18	21.60	0.00	0.00	0.00	38.91
p460	5615.00	10094.54	14149.77	437.53	452.00	644.68	21.60	0.00	0.00	0.00	34.92
p461	5615.00	10094.54	13135.46	450.90	452.00	622.18	21.60	0.00	0.00	0.00	34.92
p462	5615.00	10094.54	13572.79	450.90	452.00	644.68	21.60	0.00	0.00	0.00	34.92
p463	5615.00	10094.54	16014.16	531.97	452.00	630.28	21.60	0.00	0.00	0.00	36.09
p464	5615.00	10094.54	16748.91	1220.00	1173.05	625.98	21.60	0.00	0.00	0.00	43.78
p465	5615.00	10094.54	17856.79	1220.00	786.07	670.37	21.60	0.00	0.00	0.00	40.74
p466	5615.00	10094.54	20015.49	1206.50	878.95	789.43	21.60	0.00	0.00	0.00	39.73
p467	5615.00	10675.27	21429.19	1138.88	1631.95	963.79	21.60	0.00	0.00	0.00	43.64
p468	5615.00	11765.96	22761.32	1167.25	1714.27	2379.60	27.28	0.00	0.00	0.00	44.97
p469	5615.00	12479.33	24090.11	1374.25	1933.60	3396.62	48.88	0.00	0.00	0.00	45.80
p470	5615.00	12728.56	26148.32	1579.75	2200.00	3836.33	70.48	0.00	80.15	0.00	49.35
p471	5615.00	12761.72	27440.55	1758.38	2200.00	4296.02	222.75	0.00	220.13	0.00	61.10
p472	5615.00	12761.72	27675.02	1841.00	2200.00	4468.57	270.00	0.00	783.91	51.00	62.40
p473	5615.00	12761.72	27712.60	1841.00	2200.00	4494.44	270.00	0.00	1767.89	51.00	84.19
p474	5615.00	12761.72	27712.60	1841.00	2200.00	4495.91	270.00	0.00	1662.20	60.24	71.60
p475	5615.00	12761.72	27712.60	1841.00	2200.00	4415.82	183.41	0.00	332.09	9.28	59.61
p476	5615.00	12761.72	26038.49	1361.00	2200.00	3935.64	56.18	0.00	17.16	0.00	48.61
p477	5615.00	12761.72	24794.74	1169.00	2200.00	3131.26	56.18	0.00	0.00	0.00	44.67
p478	5615.00	12761.72	24794.74	1169.00	2200.00	3329.80	56.18	0.00	0.00	0.00	53.67
p479	5615.00	12633.59	22993.50	1129.40	1933.60	2450.00	21.60	0.00	0.00	0.00	45.50
p480	5615.00	11890.35	21717.22	1124.00	1663.90	1168.04	21.60	0.00	0.00	0.00	43.80

p481	5615.00	11307.82	18676.51	1124.00	1173.05	798.73	21.60	0.00	0.00	0.00	42.13
p482	5615.00	11231.74	16631.75	946.93	452.00	755.48	21.60	0.00	0.00	0.00	39.33
p483	5615.00	11185.48	14122.80	424.15	452.00	710.48	21.60	0.00	0.00	0.00	34.92
p484	5615.00	11185.48	12941.39	437.53	452.00	687.98	21.60	0.00	0.00	0.00	34.92
p485	5615.00	11185.48	12948.61	450.90	452.00	665.48	21.60	0.00	0.00	0.00	34.92
p486	5615.00	11185.48	13866.02	450.90	452.00	687.98	21.60	0.00	0.00	0.00	34.92
p487	5615.00	11185.48	15591.87	531.97	878.95	663.05	21.60	0.00	0.00	0.00	38.71
p488	5615.00	11185.48	16061.62	1220.00	1600.00	936.67	21.60	0.00	0.00	0.00	44.62
p489	5615.00	11187.29	17335.66	1220.00	1356.39	709.51	21.60	0.00	0.00	0.00	40.74
p490	5615.00	11235.35	19633.68	1056.97	878.95	845.48	21.60	0.00	0.00	0.00	38.80
p491	5615.00	11483.05	21251.49	1138.88	1650.38	1068.79	21.60	0.00	0.00	0.00	43.54
p492	5615.00	12322.55	23001.84	1167.25	1786.02	2586.03	43.20	0.00	0.00	0.00	45.70
p493	5615.00	13070.70	24956.80	1374.25	2137.69	3640.94	72.94	0.00	0.00	0.00	49.38
p494	5615.00	13194.84	27074.79	1579.75	2580.83	4188.78	240.02	0.00	77.82	0.00	49.81
p495	5615.00	13288.96	28283.96	1758.38	2580.83	4622.33	694.22	0.00	761.59	51.00	63.34
p496	5615.00	13288.96	28431.63	1841.00	2580.83	4773.49	750.06	0.00	2596.46	51.00	70.38
p497	5615.00	13288.96	28431.63	1841.00	2580.83	4824.70	750.06	0.00	3404.89	51.00	93.90
p498	5615.00	13288.96	28431.63	1841.00	2580.83	4824.70	750.06	0.00	2736.16	60.14	72.96
p499	5615.00	13288.96	28431.63	1841.00	2580.83	4739.36	629.42	0.00	817.53	10.16	61.73
p500	5615.00	13288.96	27193.15	1361.00	2580.83	4272.34	201.65	0.00	17.16	0.00	49.66
p501	5615.00	13288.96	25642.12	1265.00	2306.63	3777.16	56.18	0.00	0.00	0.00	47.50
p502	5615.00	13219.55	25642.12	1265.00	2200.00	3396.02	56.18	0.00	0.00	0.00	50.93
p503	5615.00	12749.56	23660.85	1225.40	1933.60	2869.61	21.60	0.00	0.00	0.00	46.43
p504	5615.00	11514.43	22457.01	1220.00	1663.90	1660.14	21.60	0.00	0.00	0.00	44.62
p505	5615.00	10685.85	20748.69	1028.00	1600.00	818.40	21.60	0.00	0.00	0.00	42.67
p506	5615.00	10621.78	18568.99	1028.00	1173.05	773.40	21.60	0.00	0.00	0.00	40.74
p507	5615.00	10621.78	16823.36	505.22	452.00	728.40	21.60	0.00	0.00	0.00	38.76
p508	5615.00	10621.78	14623.25	450.90	452.00	700.90	21.60	0.00	0.00	0.00	34.92
p509	5615.00	10621.78	13954.88	450.90	452.00	678.40	21.60	0.00	0.00	0.00	34.92
p510	5615.00	10621.78	14381.80	450.90	452.00	700.90	21.60	0.00	0.00	0.00	34.92
p511	5615.00	10621.78	16347.89	531.97	474.15	679.48	21.60	0.00	0.00	0.00	36.86
p512	5615.00	10621.78	16818.61	1220.00	1195.20	684.01	21.60	0.00	0.00	0.00	44.62
p513	5615.00	10622.85	17654.42	1220.00	1600.00	719.02	21.60	0.00	0.00	0.00	40.74
p514	5615.00	10623.93	19864.83	1206.50	1600.00	906.61	21.60	0.00	0.00	0.00	40.74
p515	5615.00	10999.69	22192.32	1056.25	1650.38	2213.18	21.60	0.00	0.00	0.00	44.62
p516	5615.00	12229.92	23812.57	1263.25	1770.43	3139.33	43.20	0.00	0.00	0.00	45.62
p517	5615.00	13224.93	25436.05	1470.25	2119.07	3781.26	72.94	0.00	0.00	0.00	48.66
p518	5615.00	13295.42	27310.47	1675.75	2494.61	4328.77	230.83	0.00	351.43	0.00	49.95
p519	5615.00	13306.20	28431.87	1841.00	2559.17	4830.83	665.73	0.00	1220.56	51.00	68.09
p520	5615.00	13306.20	28431.93	1841.00	2559.17	4978.30	721.37	0.00	2511.61	51.00	72.92
p521	5615.00	13306.20	28431.96	1841.00	2559.17	4978.30	721.37	0.00	2951.70	51.00	87.79
p522	5615.00	13306.20	28431.96	1841.00	2559.17	4978.30	721.37	0.00	2223.51	51.00	71.44
p523	5615.00	13306.20	28431.92	1841.00	2559.17	4892.96	643.02	0.00	527.50	0.00	61.65
p524	5615.00	13306.20	27048.92	1310.96	2559.17	4371.11	192.46	0.00	17.16	0.00	49.50

p525	5615.00	13306.20	25111.90	1169.00	2365.13	3851.07	56.17	0.00	0.00	0.00	49.17
p526	5615.00	13111.31	24736.79	1169.00	2225.11	3172.68	56.17	0.00	0.00	0.00	49.17
p527	5615.00	12563.66	23038.10	1129.40	1933.60	2106.48	21.61	0.00	0.00	0.00	45.52
p528	5615.00	11629.66	21405.42	1124.00	1663.90	884.33	21.61	0.00	0.00	0.00	43.25
p529	5615.00	10950.60	19174.38	1124.00	1038.86	801.31	21.61	0.00	0.00	0.00	40.74
p530	5615.00	10834.95	16751.33	1028.00	546.47	756.31	21.61	0.00	0.00	0.00	40.74
p531	5615.00	10816.91	14557.48	946.93	452.00	711.31	21.60	0.00	0.00	0.00	40.51
p532	5615.00	10806.09	13322.32	437.53	452.00	683.81	21.61	0.00	0.00	0.00	34.92
p533	5615.00	10806.09	12688.25	450.90	452.00	661.31	21.62	0.00	0.00	0.00	34.92
p534	5615.00	10806.09	12679.61	450.90	452.00	661.31	21.64	0.00	0.00	0.00	34.92
p535	5615.00	10806.09	13171.28	450.90	452.00	635.68	21.64	0.00	0.00	0.00	34.92
p536	5615.00	10806.09	13857.70	531.97	452.00	645.82	21.64	0.00	0.00	0.00	38.60
p537	5615.00	10806.09	15261.55	1220.00	452.00	683.51	21.64	0.00	0.00	0.00	40.74
p538	5615.00	10806.09	18675.70	1206.50	910.10	817.96	21.64	0.00	0.00	0.00	40.74
p539	5615.00	11226.73	21558.87	1138.88	1631.95	1011.06	21.64	0.00	0.00	0.00	44.23
p540	5615.00	12292.47	23368.46	1167.25	1714.27	2021.07	40.06	0.00	0.00	0.00	44.62
p541	5615.00	13155.68	24687.78	1374.25	1933.60	3589.90	61.68	0.00	0.00	0.00	46.46
p542	5615.00	13374.75	26396.96	1579.75	2200.00	4081.19	138.68	0.00	192.54	0.00	49.14
p543	5615.00	13403.61	27721.36	1758.38	2200.00	4544.38	396.13	0.00	653.61	0.00	66.64
p544	5615.00	13421.65	27798.29	1841.00	2200.00	4680.34	443.48	0.00	1351.13	51.00	63.98
p545	5615.00	13421.65	27798.83	1841.00	2200.00	4740.82	443.51	0.00	2226.33	51.00	78.04
p546	5615.00	13421.65	27798.95	1841.00	2200.00	4740.82	443.51	0.00	2265.11	51.00	81.74
p547	5615.00	13421.65	27798.73	1841.00	2200.00	4655.48	382.26	0.00	1122.82	51.00	65.04
p548	5615.00	13421.65	27163.66	1529.62	2200.00	4197.70	115.92	0.00	107.62	0.00	49.75
p549	5615.00	13421.65	25578.47	1169.00	2200.00	3767.32	60.56	0.00	0.00	0.00	49.22
p550	5615.00	13159.43	25034.38	1169.00	2200.00	3125.54	60.56	0.00	0.00	0.00	49.17
p551	5615.00	12658.84	23127.11	1129.40	1933.60	2428.30	21.75	0.00	0.00	0.00	45.52
p552	5615.00	11666.21	21764.99	1124.00	1663.90	1217.52	21.75	0.00	0.00	0.00	43.80
p553	5615.00	10603.84	19552.68	1124.00	1600.00	804.14	21.75	0.00	0.00	0.00	41.22
p554	5615.00	10277.83	17892.17	1028.00	878.95	762.27	21.75	0.00	0.00	0.00	40.35
p555	5615.00	10267.06	15410.87	1028.00	1335.53	717.57	21.75	0.00	0.00	0.00	41.83
p556	5615.00	10260.59	14176.85	960.30	614.48	690.07	21.75	0.00	0.00	0.00	39.65
p557	5615.00	10260.59	13555.55	450.90	452.00	667.57	21.90	0.00	0.00	0.00	34.97
p558	5615.00	10260.59	13106.43	450.90	452.00	667.57	22.04	0.00	0.00	0.00	34.92
p559	5615.00	10260.59	13452.78	450.90	452.00	659.30	22.19	0.00	0.00	0.00	34.92
p560	5615.00	10260.59	13328.01	450.90	452.00	646.92	22.19	0.00	0.00	0.00	34.92
p561	5615.00	10291.81	14464.85	531.97	452.00	667.37	22.19	0.00	0.00	0.00	38.51
p562	5615.00	10329.49	17165.22	1206.50	1173.05	751.69	22.19	0.00	0.00	0.00	41.13
p563	5615.00	10531.03	20715.83	1138.88	1631.95	934.79	22.19	0.00	0.00	0.00	43.17
p564	5615.00	11757.89	23079.71	1167.25	1740.24	2322.50	39.81	0.00	0.00	0.00	44.80
p565	5615.00	13242.87	24551.06	1374.25	2038.84	3441.91	61.71	0.00	0.00	0.00	45.97
p566	5615.00	13667.14	26783.47	1579.75	2492.08	3965.09	158.10	0.00	70.08	0.00	50.60
p567	5615.00	13887.30	28054.78	1758.38	2766.28	4476.86	460.35	0.00	374.79	0.00	60.53
p568	5615.00	13898.08	28470.38	1841.00	2766.28	4756.28	509.38	0.00	1249.87	51.00	64.98

p569	5615.00	13898.08	28478.73	1841.00	2766.28	4874.77	510.27	0.00	2430.84	51.00	77.50
p570	5615.00	13898.08	28480.61	1841.00	2766.28	4886.10	510.65	0.00	2463.58	51.00	82.56
p571	5615.00	13898.08	28480.61	1841.00	2766.28	4880.77	510.65	0.00	1768.80	51.00	67.37
p572	5615.00	13898.08	28477.91	1841.00	2766.28	4727.97	329.48	0.00	302.65	0.00	58.28
p573	5615.00	13898.08	27888.68	1841.00	2632.76	4261.10	63.83	0.00	27.69	0.00	50.60
p574	5615.00	13898.08	27295.92	1818.42	2306.63	3728.34	63.83	0.00	3.65	0.00	50.60
p575	5615.00	13655.62	25063.43	1288.38	2031.05	3146.24	56.77	0.00	0.00	0.00	49.17
p576	5615.00	12825.55	22421.61	1225.40	1700.75	1761.35	23.97	0.00	0.00	0.00	44.97
p577	5615.00	12264.77	19395.29	1220.00	1600.00	924.25	23.97	0.00	0.00	0.00	42.65
p578	5615.00	12174.55	16357.55	1138.93	878.95	842.57	21.60	0.00	0.00	0.00	40.63
p579	5615.00	12120.45	15154.82	450.90	452.00	797.57	23.97	0.00	0.00	0.00	35.46
p580	5615.00	12120.45	14089.45	450.90	452.00	752.57	26.34	0.00	0.00	0.00	35.46
p581	5615.00	12120.45	13647.68	450.90	452.00	730.07	28.70	0.00	0.00	0.00	35.46
p582	5615.00	12120.45	14080.13	450.90	452.00	696.20	28.70	0.00	0.00	0.00	35.46
p583	5615.00	12120.45	15725.19	882.18	878.95	717.10	28.70	0.00	0.00	0.00	39.40
p584	5615.00	12175.14	16539.02	1220.00	1600.00	1522.06	28.70	0.00	0.00	0.00	45.31
p585	5615.00	12256.65	18308.25	1206.50	878.95	759.45	28.70	0.00	0.00	0.00	41.17
p586	5615.00	12392.26	21155.48	1056.25	1631.95	943.60	28.70	0.00	0.00	0.00	41.71
p587	5615.00	12785.58	23301.74	1263.25	1740.48	2168.41	41.08	0.00	0.00	0.00	45.31
p588	5615.00	13814.65	25013.82	1470.25	2039.32	3617.17	67.41	0.00	0.00	0.00	47.04
p589	5615.00	14703.06	27215.65	1675.75	2493.80	4357.63	121.37	0.00	81.97	0.00	50.50
p590	5615.00	15229.67	28678.34	1841.00	2768.00	5156.67	532.40	0.00	503.55	0.00	61.69
p591	5615.00	15494.24	29153.34	1841.00	2768.00	5713.88	933.77	0.00	1353.26	51.00	67.15
p592	5615.00	15494.24	29312.38	1841.00	2768.00	5855.17	939.71	0.00	2195.29	51.00	68.32
p593	5615.00	15494.24	29453.48	1841.00	2768.00	5855.17	939.71	0.00	2754.72	51.00	87.09
p594	5615.00	15494.24	29483.85	1841.00	2768.00	5855.17	939.71	0.00	2650.74	51.00	73.90
p595	5615.00	15494.24	29483.85	1841.00	2768.00	5855.17	939.71	0.00	1717.23	51.00	67.51
p596	5615.00	15494.24	29217.56	1841.00	2768.00	5768.20	778.76	0.00	299.21	0.00	58.45
p597	5615.00	15494.24	28340.22	1841.00	2768.00	5304.63	226.50	0.00	94.96	0.00	56.66
p598	5615.00	15494.24	27945.20	1841.00	2633.24	4535.25	222.75	0.00	90.77	0.00	57.18
p599	5615.00	15298.34	25566.87	1310.96	2137.69	3364.48	32.93	0.00	0.00	0.00	49.76
p600	5615.00	14418.70	22820.35	1225.40	1700.75	2210.52	21.60	0.00	0.00	0.00	46.27
p601	5615.00	13836.34	19947.00	1220.00	1600.00	931.37	21.60	0.00	0.00	0.00	43.43
p602	5615.00	13836.34	17068.29	1138.93	878.95	849.69	21.60	0.00	0.00	0.00	40.44
p603	5615.00	13836.34	15717.71	450.90	452.00	804.69	21.60	0.00	0.00	0.00	35.91
p604	5615.00	13836.34	14836.86	450.90	452.00	759.69	21.60	0.00	0.00	0.00	35.91
p605	5615.00	13836.34	14825.57	450.90	452.00	732.19	21.60	0.00	0.00	0.00	35.91
p606	5615.00	13836.34	15308.91	450.90	452.00	713.51	21.60	0.00	0.00	0.00	35.91
p607	5615.00	13836.34	16644.43	1138.93	930.22	696.37	21.60	0.00	0.00	0.00	41.90
p608	5615.00	13836.34	17423.65	1220.00	1600.00	1621.32	21.60	0.00	0.00	0.00	46.31
p609	5615.00	13836.34	18865.09	1206.50	878.95	766.46	21.60	0.00	0.00	0.00	41.00
p610	5615.00	13836.34	21318.12	1056.25	1631.95	977.91	21.60	0.00	0.00	0.00	42.11
p611	5615.00	14017.17	23295.86	1263.25	1740.48	2046.49	21.60	0.00	0.00	0.00	45.89
p612	5615.00	14795.43	25008.28	1470.25	2039.32	3545.67	49.38	0.00	0.00	0.00	46.90

p613	5615.00	15494.24	27090.32	1675.75	2493.80	4155.45	113.59	0.00	0.00	0.00	54.07
p614	5615.00	15494.24	28393.63	1841.00	2768.00	4794.81	304.09	0.00	519.55	44.96	56.44
p615	5615.00	15494.24	28898.90	1841.00	2768.00	5117.79	750.64	0.00	1623.40	51.00	70.67
p616	5615.00	15494.24	28996.91	1841.00	2768.00	5198.00	750.64	0.00	2605.22	51.00	74.02
p617	5615.00	15494.24	29019.69	1841.00	2768.00	5198.00	750.64	0.00	3161.29	51.00	91.37
p618	5615.00	15494.24	29019.69	1841.00	2768.00	5198.00	750.64	0.00	2000.30	51.00	69.78
p619	5615.00	15494.24	28951.35	1841.00	2768.00	5111.04	631.55	0.00	510.94	0.00	62.02
p620	5615.00	15421.89	28126.97	1841.00	2633.24	4520.85	171.78	0.00	17.16	0.00	52.11
p621	5615.00	15355.10	27582.85	1841.00	2306.63	3940.95	66.76	0.00	0.00	0.00	52.29
p622	5615.00	15059.74	27484.84	1841.00	2200.00	3425.04	60.59	0.00	0.00	0.00	52.20
p623	5615.00	14296.70	25073.64	1305.56	2031.05	2930.56	49.12	0.00	0.00	0.00	50.16
p624	5615.00	13452.79	22420.85	1182.04	1700.75	1590.80	21.60	0.00	0.00	0.00	45.13
p625	5615.00	13030.76	19375.69	1124.00	1279.66	819.72	21.60	0.00	0.00	0.00	43.05
p626	5615.00	12990.53	16963.69	1042.93	558.61	774.72	21.60	0.00	0.00	0.00	41.37
p627	5615.00	12990.53	16070.69	442.74	452.00	729.72	21.60	0.00	0.00	0.00	36.40
p628	5615.00	12990.53	15185.90	450.90	452.00	702.22	21.60	0.00	0.00	0.00	36.18
p629	5615.00	12990.53	14397.22	450.90	452.00	679.72	21.60	0.00	0.00	0.00	36.18
p630	5615.00	12990.53	14695.14	450.90	452.00	665.13	21.60	0.00	0.00	0.00	36.18
p631	5615.00	12990.53	16320.32	854.88	878.95	625.55	21.60	0.00	0.00	0.00	40.20
p632	5615.00	12990.53	17252.45	1220.00	1600.00	1134.87	21.60	0.00	0.00	0.00	46.23
p633	5615.00	12990.53	18789.79	1206.50	878.95	722.79	21.60	0.00	0.00	0.00	41.50
p634	5615.00	12990.53	21550.80	1106.13	1638.47	932.27	21.60	0.00	0.00	0.00	43.06
p635	5615.00	13302.57	23558.04	1205.21	1720.80	1894.52	39.87	0.00	0.00	0.00	46.23
p636	5615.00	14167.98	25065.70	1412.21	1968.08	3413.84	61.47	0.00	0.00	0.00	48.98
p637	5615.00	14768.50	26893.95	1617.71	2200.00	3947.21	94.29	0.00	0.00	0.00	51.89
p638	5615.00	14835.58	28024.35	1791.12	2200.00	4464.06	192.14	0.00	478.80	51.00	57.50
p639	5615.00	14835.58	28431.60	1841.00	2200.00	4713.28	452.77	0.00	1406.56	51.00	81.28
p640	5615.00	14835.58	28431.60	1841.00	2200.00	4749.81	452.77	0.00	1392.21	51.00	60.30
p641	5615.00	14835.58	28431.60	1841.00	2200.00	4749.81	452.77	0.00	1459.66	51.00	69.05
p642	5615.00	14835.58	28431.60	1841.00	2200.00	4749.81	452.77	0.00	1540.14	51.00	84.56
p643	5615.00	14835.58	28431.60	1841.00	2200.00	4663.51	405.52	0.00	582.80	21.35	66.14
p644	5615.00	14632.66	27727.20	1787.80	2200.00	4087.94	103.44	0.00	40.12	0.00	51.30
p645	5615.00	14445.34	27112.71	1276.77	2200.00	3519.53	56.18	0.00	0.00	0.00	51.01
p646	5615.00	14380.69	26263.94	1253.39	2200.00	2981.82	56.18	0.00	0.00	0.00	51.01
p647	5615.00	13827.17	23633.83	1213.79	1933.60	2031.44	21.60	0.00	0.00	0.00	47.69
p648	5615.00	12787.96	20963.52	1208.39	1663.90	841.57	21.60	0.00	0.00	0.00	44.43
p649	5615.00	12309.09	17630.58	1039.61	1173.05	782.53	21.60	0.00	0.00	0.00	42.67
p650	5615.00	12309.09	15675.79	505.22	452.00	737.53	21.60	0.00	0.00	0.00	40.41
p651	5615.00	12309.09	13467.15	424.15	452.00	692.53	21.60	0.00	0.00	0.00	36.54
p652	5615.00	12309.09	11984.38	449.27	452.00	670.03	21.60	0.00	0.00	0.00	36.54
p653	5615.00	12309.09	11640.58	450.90	452.00	647.53	21.60	0.00	0.00	0.00	36.54
p654	5615.00	12309.09	12588.01	450.90	452.00	668.63	21.60	0.00	0.00	0.00	36.54
p655	5615.00	12309.09	14984.62	531.97	452.00	643.02	21.60	0.00	0.00	0.00	39.95
p656	5615.00	12309.09	15901.09	1220.00	1173.05	1043.58	21.60	0.00	0.00	0.00	46.69

p657	5615.00	12309.09	17277.53	1184.05	452.00	704.61	21.60	0.00	0.00	0.00	40.60
p658	5615.00	12309.09	19886.34	990.79	878.95	826.24	21.60	0.00	0.00	0.00	40.60
p659	5615.00	12784.25	21618.18	1066.23	1650.38	1149.33	21.60	0.00	0.00	0.00	46.69
p660	5615.00	13777.87	23102.62	1251.64	1732.70	1894.31	43.20	0.00	0.00	0.00	45.61
p661	5615.00	14341.92	24447.21	1458.64	2031.05	3481.20	64.80	0.00	0.00	0.00	49.31
p662	5615.00	14341.92	26422.30	1664.14	2200.00	3937.70	86.40	0.00	262.84	12.75	51.18
p663	5615.00	14341.92	27564.94	1831.02	2200.00	4380.69	222.75	0.00	942.71	51.00	73.34
p664	5615.00	14341.92	27712.60	1841.00	2200.00	4488.39	270.00	0.00	1826.89	51.00	70.77
p665	5615.00	14341.92	27712.60	1841.00	2200.00	4488.39	270.00	0.00	2073.08	51.00	88.44
p666	5615.00	14341.92	27712.60	1841.00	2200.00	4465.89	270.00	0.00	1572.77	51.00	71.39
p667	5615.00	14341.92	27712.60	1841.00	2200.00	4330.50	115.12	0.00	198.90	0.00	56.71
p668	5615.00	14199.04	26947.90	1310.96	2200.00	3950.30	67.87	0.00	17.16	0.00	51.37
p669	5615.00	14000.08	26254.26	1177.08	2200.00	3635.16	55.52	0.00	0.00	0.00	50.73
p670	5615.00	13723.40	26043.40	1177.08	2200.00	3050.57	49.34	0.00	0.00	0.00	52.00
p671	5615.00	13185.04	23572.74	1137.48	1933.60	2007.11	21.60	0.00	0.00	0.00	48.05
p672	5615.00	12606.05	20853.78	1132.08	1663.90	802.82	21.60	0.00	0.00	0.00	44.53
p673	5615.00	12344.56	18068.75	1115.92	944.83	757.82	21.60	0.00	0.00	0.00	42.42
p674	5615.00	12344.56	16550.16	505.22	452.00	712.82	21.60	0.00	0.00	0.00	39.85
p675	5615.00	12344.56	15473.92	424.15	452.00	668.44	21.60	0.00	0.00	0.00	39.11
p676	5615.00	12344.56	13886.90	438.64	452.00	645.94	21.60	0.00	0.00	0.00	36.36
p677	5615.00	12344.56	13488.22	450.90	452.00	623.44	21.60	0.00	0.00	0.00	36.36
p678	5615.00	12344.56	14285.97	450.90	452.00	622.58	21.60	0.00	0.00	0.00	36.36
p679	5615.00	12344.56	16053.18	866.31	573.80	587.90	21.60	0.00	0.00	0.00	40.40
p680	5615.00	12344.56	16936.42	1220.00	1294.85	1032.58	21.60	0.00	0.00	0.00	46.46
p681	5615.00	12344.56	18114.34	1036.00	573.80	658.74	21.60	0.00	0.00	0.00	40.40
p682	5615.00	12344.56	20147.24	1206.50	878.95	780.26	21.60	0.00	0.00	0.00	41.29
p683	5615.00	12460.21	21818.88	1131.91	1650.38	959.59	21.60	0.00	0.00	0.00	46.22
p684	5615.00	12911.90	23331.17	1175.33	1732.70	2345.22	40.11	0.00	0.00	0.00	46.46
p685	5615.00	13260.10	24845.07	1382.33	2031.05	3424.24	61.71	0.00	0.00	0.00	51.04
p686	5615.00	13260.10	26773.67	1587.83	2200.00	3789.68	83.31	0.00	179.74	0.00	50.15
p687	5615.00	13260.10	27564.94	1765.34	2200.00	4125.08	222.75	0.00	591.07	7.92	67.00
p688	5615.00	13260.10	27712.60	1841.00	2200.00	4178.06	270.00	0.00	1138.65	47.56	67.45
p689	5615.00	13260.10	27712.60	1841.00	2200.00	4178.06	270.00	0.00	1760.27	59.96	88.86
p690	5615.00	13260.10	27712.60	1841.00	2200.00	4155.56	232.08	0.00	1349.20	47.56	69.82
p691	5615.00	13260.10	27574.21	1544.92	2200.00	3867.55	55.62	0.00	131.19	0.00	51.22
p692	5615.00	13260.10	25296.97	1352.92	2200.00	3466.61	46.29	0.00	5.31	0.00	49.92
p693	5615.00	13260.10	24283.01	1169.00	2200.00	3055.23	33.94	0.00	0.00	0.00	49.92
p694	5615.00	13158.00	23579.23	1153.60	2031.05	2688.03	21.60	0.00	0.00	0.00	49.51
p695	5615.00	13065.37	22144.21	1114.00	1700.75	1825.19	21.60	0.00	0.00	0.00	46.94
p696	5615.00	12569.43	20482.32	1114.00	1600.00	721.40	21.60	0.00	0.00	0.00	44.18
p697	5615.00	12119.68	18376.11	1114.00	878.95	675.95	21.60	0.00	0.00	0.00	41.92
p698	5615.00	12119.68	16751.97	1018.00	452.00	630.95	21.60	0.00	0.00	0.00	41.68
p699	5615.00	12119.68	14954.48	924.03	452.00	603.45	21.60	0.00	0.00	0.00	40.40
p700	5615.00	12119.68	14316.51	436.03	452.00	580.95	21.60	0.00	0.00	0.00	39.99

p701	5615.00	12119.68	12992.18	449.90	452.00	558.45	21.60	0.00	0.00	0.00	36.36
p702	5615.00	12119.68	12344.40	450.40	452.00	535.95	21.60	0.00	0.00	0.00	36.36
p703	5615.00	12119.68	13250.11	450.90	452.00	558.45	21.60	0.00	0.00	0.00	36.36
p704	5615.00	12119.68	14390.83	511.08	452.00	521.11	21.60	0.00	0.00	0.00	40.40
p705	5615.00	12119.68	15167.08	997.88	452.00	566.11	21.60	0.00	0.00	0.00	40.40
p706	5615.00	12119.68	17813.87	1215.50	798.32	655.25	21.60	0.00	0.00	0.00	42.23
p707	5615.00	12119.68	20471.70	1133.38	1551.31	770.86	21.60	0.00	0.00	0.00	42.61
p708	5615.00	12569.43	22771.17	1152.25	1714.27	1822.95	21.60	0.00	0.00	0.00	46.46
p709	5615.00	13046.79	24297.65	1359.25	1933.60	2831.06	43.20	0.00	0.00	0.00	47.46
p710	5615.00	13046.79	26303.18	1565.75	2200.00	3311.21	64.80	0.00	0.00	0.00	52.38
p711	5615.00	13046.79	27341.93	1753.88	2200.00	3595.66	133.65	0.00	214.08	0.00	53.08
p712	5615.00	13046.79	27596.77	1841.00	2200.00	3786.36	270.00	0.00	747.59	29.51	71.59
p713	5615.00	13046.79	27712.60	1841.00	2200.00	3810.74	270.00	0.00	1333.91	29.51	84.03
p714	5615.00	13046.79	27712.60	1841.00	2200.00	3801.83	270.00	0.00	1084.13	29.51	71.05
p715	5615.00	13046.79	27712.60	1841.00	2200.00	3705.88	112.05	0.00	210.33	0.00	56.47
p716	5615.00	13046.79	26369.43	1361.00	2200.00	3427.45	64.80	0.00	17.16	0.00	50.66
p717	5615.00	13046.79	24942.25	1169.00	2200.00	3028.45	21.60	0.00	0.00	0.00	50.55
p718	5615.00	12660.69	23717.62	1057.60	2031.05	2590.56	7.45	0.00	0.00	0.00	48.49
p719	5615.00	11730.22	22566.55	1018.00	1700.75	1679.42	7.45	0.00	0.00	0.00	47.87
p720	5615.00	10782.60	20728.70	1018.00	1600.00	626.33	7.45	0.00	0.00	0.00	44.49
p721	5615.00	10144.64	18723.11	1018.00	878.95	574.64	7.45	0.00	0.00	0.00	42.37
p722	5615.00	9912.21	16873.85	1018.00	452.00	528.15	7.45	0.00	0.00	0.00	41.66
p723	5615.00	9912.21	15165.84	1018.00	479.84	500.65	7.45	0.00	0.00	0.00	42.42
p724	5615.00	9912.21	13682.62	936.93	452.00	478.15	7.45	0.00	0.00	0.00	40.60
p725	5615.00	9912.21	12630.17	422.65	452.00	455.65	7.45	0.00	0.00	0.00	36.36
p726	5615.00	9912.21	11773.54	423.15	452.00	449.32	7.45	0.00	0.00	0.00	36.36
p727	5615.00	9912.21	12252.14	423.65	452.00	449.32	7.45	0.00	0.00	0.00	36.36
p728	5615.00	9912.21	13000.86	424.15	452.00	448.94	7.45	0.00	0.00	0.00	36.36
p729	5615.00	9912.21	13975.69	620.64	452.00	455.99	7.45	0.00	0.00	0.00	40.40
p730	5615.00	9912.21	16639.39	1028.00	1173.05	482.65	7.45	0.00	0.00	0.00	42.50
p731	5615.00	9912.21	19144.89	1028.00	1188.99	565.99	7.45	0.00	0.00	0.00	42.42
p732	5615.00	10461.97	21160.71	1019.00	1600.00	660.17	7.45	0.00	0.00	0.00	44.70
p733	5615.00	11282.20	22541.58	1024.50	1650.38	1742.35	7.45	0.00	0.00	0.00	46.46
p734	5615.00	11530.10	23862.97	1039.50	1732.70	2616.11	14.90	0.00	0.00	0.00	47.27
p735	5615.00	11530.10	25099.74	1054.50	2031.05	2824.62	22.35	0.00	0.00	0.00	48.85
p736	5615.00	11530.10	25912.51	1068.50	2200.00	2964.37	29.80	0.00	360.63	23.33	52.30
p737	5615.00	11530.10	26058.60	1073.00	2200.00	3024.59	93.14	0.00	1081.33	23.33	90.49
p738	5615.00	11530.10	26058.60	1073.00	2200.00	3047.09	93.14	0.00	776.36	23.33	69.45
p739	5615.00	11530.10	25643.44	1073.00	2200.00	2901.13	29.80	0.00	102.98	0.00	50.32
p740	5615.00	11530.10	24951.50	1033.40	2200.00	1776.86	22.35	0.00	0.00	0.00	47.10
p741	5615.00	11530.10	23741.14	1033.40	2200.00	1635.60	14.90	0.00	0.00	0.00	48.46
p742	5615.00	11438.89	22940.69	1013.00	1933.60	1349.15	7.45	0.00	0.00	0.00	48.04
p743	5615.00	11166.54	21104.58	1013.00	1663.90	334.02	0.00	0.00	0.00	0.00	45.60
p744	5615.00	10983.76	17590.25	1013.00	1600.00	237.79	0.00	0.00	0.00	0.00	23.39

APPENDIX C : VALIDATION OF MODEL'S OBTAINED OUTPUT S

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1. MODEL VS. REAL TOTAL OUTPUT

Hour	CCGT90 [Mw]	CCLE90 [Mw]	CLLIG [Mw]	DSL [Mw]	GSNONR [Mw]	GSREH [Mw]	GSSUP [Mw]	NUC [Mw]	SCGT90 [Mw]	SCLE90 [Mw]	Total output_Model [Mw]	Total output_Real [Mw]
p289	20711.14	638.77	10820.10	0.00	0.00	922.49	452.93	5615.00	0.00	0.00	39160.42	38473.00
p290	18198.68	624.63	10820.10	0.00	0.00	877.49	452.00	5615.00	0.00	0.00	36587.90	37049.00
p291	16126.82	973.57	10820.10	0.00	0.00	832.49	465.57	5615.00	0.00	0.00	34833.55	35849.00
p292	15501.97	428.65	10820.10	0.00	0.00	799.59	452.00	5615.00	0.00	0.00	33617.31	35723.00
p293	14908.29	428.65	10820.10	0.00	0.00	605.94	452.00	5615.00	0.00	0.00	32829.98	36964.00
p294	15331.54	428.65	10820.10	0.00	0.00	628.44	452.00	5615.00	0.00	0.00	33275.73	38903.00
p295	16344.90	973.57	10820.10	0.00	0.00	689.01	533.92	5615.00	0.00	0.00	34976.49	39637.00
p296	17209.90	1073.00	10820.10	0.00	0.00	767.07	888.28	5615.00	0.00	0.00	36373.35	42100.00
p297	19111.71	546.59	10820.10	0.00	0.00	845.14	680.41	5615.00	0.00	0.00	37618.95	45311.00
p298	20898.89	1073.00	10820.10	0.00	0.00	890.14	1483.78	5615.00	0.00	0.00	40780.91	49755.00
p299	23192.28	1073.00	11242.50	0.00	0.00	1133.04	1726.07	5615.00	0.00	0.00	43981.89	54770.00
p300	23894.28	1180.00	12200.64	0.00	0.00	2476.48	2190.09	5615.00	86.40	0.00	47642.89	58259.00
p301	25313.54	1636.19	12732.84	0.00	0.00	3451.28	2633.24	5615.00	173.12	0.00	51555.21	61585.00
p302	26938.02	1841.00	13128.64	0.00	0.00	3768.20	2768.00	5615.00	182.40	424.42	54665.68	64219.00
p303	27888.80	1841.00	13260.10	51.00	0.00	4319.14	2768.00	5615.00	507.00	1185.57	57435.61	65828.00
p304	28431.60	1841.00	13260.10	51.00	0.00	4613.00	2768.00	5615.00	570.00	1968.42	59118.12	66555.00
p305	28431.60	1841.00	13260.10	186.04	0.00	4667.72	2768.00	5615.00	570.00	2723.96	60063.42	66123.00
p306	28431.60	1841.00	13260.10	171.90	0.00	4722.44	2768.00	5615.00	570.00	2523.41	59903.45	64135.00
p307	28431.60	1841.00	13260.10	47.18	0.00	4755.92	2768.00	5615.00	570.00	1787.21	59076.00	60598.00
p308	28115.63	1841.00	13181.30	0.00	0.00	4645.46	2768.00	5615.00	429.24	182.86	56778.49	58038.00
p309	26303.90	1636.19	12985.40	0.00	0.00	4011.55	2768.00	5615.00	0.00	0.00	53320.04	53760.00
p310	25816.78	1073.00	12750.57	0.00	0.00	3481.32	2633.24	5615.00	0.00	0.00	51369.91	48921.00
p311	23109.71	1073.00	12077.47	0.00	0.00	2824.77	2359.04	5615.00	0.00	0.00	47058.98	43264.00

p312	19968.01	1073.00	11781.22	0.00	0.00	1553.65	1779.61	5615.00	0.00	0.00	41770.48	39001.00

2. MODEL VS. REAL OUTPUT OF COMBINED CYCLE UNITS

Period	Total CCGT90 [Mw]	Total CCLE90 [Mw]	Total Combined Cycle_ Model [Mw]	Total Combined Cycle_ Real [Mw]
p289	20711.14	638.77	21349.90	18287.00
p290	18198.68	624.63	18823.31	17795.00
p291	16126.82	973.57	17100.39	17063.00
p292	15501.97	428.65	15930.62	17089.00
p293	14908.29	428.65	15336.94	17791.00
p294	15331.54	428.65	15760.19	18534.00
p295	16344.90	973.57	17318.47	18813.00
p296	17209.90	1073.00	18282.90	20178.00
p297	19111.71	546.59	19658.30	22275.00
p298	20898.89	1073.00	21971.89	24817.00
p299	23192.28	1073.00	24265.28	28252.00
p300	23894.28	1180.00	25074.28	29914.00
p301	25313.54	1636.19	26949.73	30910.00
p302	26938.02	1841.00	28779.02	31647.00
p303	27888.80	1841.00	29729.80	32095.00
p304	28431.60	1841.00	30272.60	32279.00
p305	28431.60	1841.00	30272.60	32172.00
p306	28431.60	1841.00	30272.60	31991.00
p307	28431.60	1841.00	30272.60	30963.00
p308	28115.63	1841.00	29956.63	29932.00
p309	26303.90	1636.19	27940.09	27210.00
p310	25816.78	1073.00	26889.78	24719.00
p311	23109.71	1073.00	24182.71	21148.00
p312	19968.01	1073.00	21041.01	18657.00

3. MODEL VS. REAL OUTPUT OF GAS STEAM UNITS

Period	GSNONR [Mw]	GSREH [Mw]	GSSUP [Mw]	Total gas steam _ Model [Mw]	Total gas steam _ Real [Mw]
p289	0.00	922.49	452.93	1375.42	2503.00
p290	0.00	877.49	452.00	1329.49	2227.00
p291	0.00	832.49	465.57	1298.06	2227.00
p292	0.00	799.59	452.00	1251.59	2164.00
p293	0.00	605.94	452.00	1057.94	2203.00
p294	0.00	628.44	452.00	1080.44	2356.00
p295	0.00	689.01	533.92	1222.92	2554.00
p296	0.00	767.07	888.28	1655.35	2692.00
p297	0.00	845.14	680.41	1525.55	2876.00

p298	0.00	890.14	1483.78	2373.92	3453.00
p299	0.00	1133.04	1726.07	2859.11	4511.00
p300	0.00	2476.48	2190.09	4666.57	5924.00
p301	0.00	3451.28	2633.24	6084.52	8179.00
p302	0.00	3768.20	2768.00	6536.20	9912.00
p303	0.00	4319.14	2768.00	7087.14	10997.00
p304	0.00	4613.00	2768.00	7381.00	11471.00
p305	0.00	4667.72	2768.00	7435.72	11089.00
p306	0.00	4722.44	2768.00	7490.44	9256.00
p307	0.00	4755.92	2768.00	7523.92	6748.00
p308	0.00	4645.46	2768.00	7413.46	5190.00
p309	0.00	4011.55	2768.00	6779.55	4211.00
p310	0.00	3481.32	2633.24	6114.56	3210.00
p311	0.00	2824.77	2359.04	5183.81	2671.00
p312	0.00	1553.65	1779.61	3333.25	2679.00

4. MODEL VS. REAL OUTPUT OF COAL UNITS

Period	Total coal _ Model [Mw]	Total coal _ Real [Mw]
p289	10820.10	17683.00
p290	10820.10	17027.00
p291	10820.10	16559.00
p292	10820.10	16470.00
p293	10820.10	16970.00
p294	10820.10	18013.00
p295	10820.10	18270.00
p296	10820.10	19230.00
p297	10820.10	20160.00
p298	10820.10	21485.00
p299	11242.50	22007.00
p300	12200.64	22421.00
p301	12732.84	22496.00
p302	13128.64	22660.00
p303	13260.10	22736.00
p304	13260.10	22805.00
p305	13260.10	22862.00
p306	13260.10	22888.00
p307	13260.10	22887.00
p308	13181.30	22916.00
p309	12985.40	22339.00
p310	12750.57	20992.00
p311	12077.47	19445.00
p312	11781.22	17665.00

APPENDIX D

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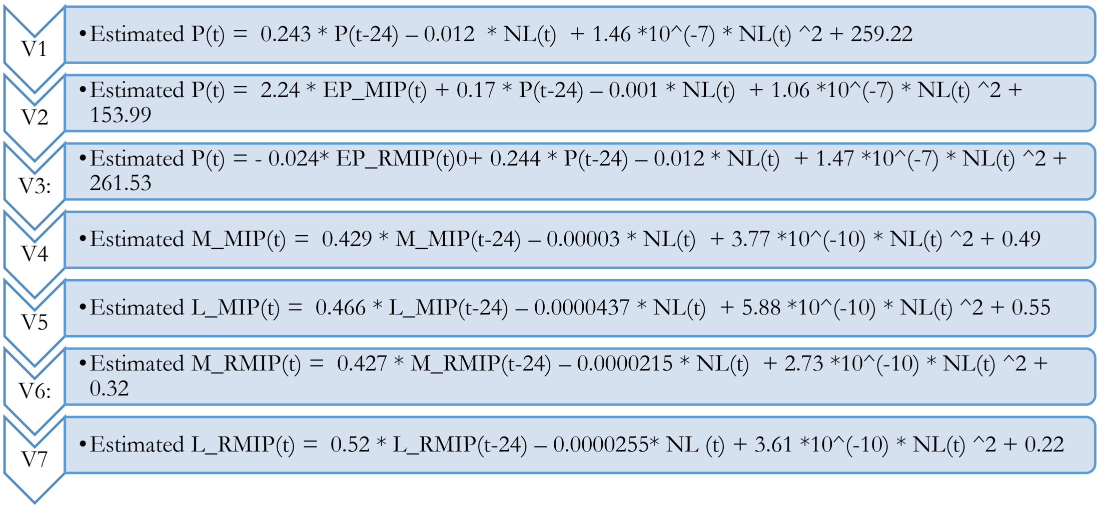
1. Case 1: Week 1 & 2 vs. Week 3 & 4

This section presents results from econometric models of case 1, summarized in Figure 0.1, Figure 0.2, and Figure 0.3 as follows:



V1
- Estimated P(t) = 0.243 * P(t-24) – 0.012 * NL(t) + 1.46 *10^(-7) * NL(t) ^2 + 259.22

V2
- Estimated P(t) = 2.24 * EP_MIP(t) + 0.17 * P(t-24) – 0.001 * NL(t) + 1.06 *10^(-7) * NL(t) ^2 + 153.99

V3:
- Estimated P(t) = - 0.024* EP_RMIP(t)0+ 0.244 * P(t-24) – 0.012 * NL(t) + 1.47 *10^(-7) * NL(t) ^2 + 261.53

V4
- Estimated M_MIP(t) = 0.429 * M_MIP(t-24) – 0.00003 * NL(t) + 3.77 *10^(-10) * NL(t) ^2 + 0.49

V5
- Estimated L_MIP(t) = 0.466 * L_MIP(t-24) – 0.0000437 * NL(t) + 5.88 *10^(-10) * NL(t) ^2 + 0.55

V6:
- Estimated M_RMIP(t) = 0.427 * M_RMIP(t-24) – 0.0000215 * NL(t) + 2.73 *10^(-10) * NL(t) ^2 + 0.32

V7
- Estimated L_RMIP(t) = 0.52 * L_RMIP(t-24) – 0.0000255* NL (t) + 3.61 *10^(-10) * NL(t) ^2 + 0.22

Figure 0.1 Summary of models obtained using first data set (Case 1):

V1
- P(t) = Estimated P(t) +0.25

V2
- P(t) = 0.99 * Estimated P(t) - 0.16

V3
- P(t) = 1.01 * Estimated P(t) + 0.39

V4
- P(t) = 1.29 * Estimated P(t) - 9.92

V5
- P(t) = 1.6 * Estimated P(t) -20.13

V6
- P(t) = 1.17 * Estimated P(t) -3.76

V7
- P(t) = 1.39 * Estimated P(t) -11.53

Figure 0.2: Validation of the obtained model with the first data set (Case 1)

V1
- P(t) = 0.79 * Estimated P(t) +7.94

V2
- P(t) = 0.54 * Estimated P(t) +15.26

V3
- P(t) = 0.79 * Estimated P(t) +8.08

V4
- P(t) = 0.85 * Estimated P(t) + 4.47

V5
- P(t) = 0.93 * Estimated P(t) +2.5

V6
- P(t) = 0.95 * Estimated P(t) +1.83

V7
- P(t) = Estimated price(t) +0.22

Figure 0.3: Validation of the obtained model with the second data set (Case 1)

2. Case 2: Week 3 & 4 vs. Week 1 & 2

This section presents results from econometric models of case 2, summarized in Figure 0.4, Figure 0.5, and Figure 0.6 as follows:

V1
- Estimated P(t) = 0.205 * P(t-24) – 0.00785 * NL(t) + 9.86 *10^(-8) * NL(t) ^2 + 174.68

V2
- Estimated P(t) = 0.472 * EP_MIP(t) + 0.145 * P(t-24) – 0.00773 * NL(t) + 9.32 *10^(-8) * NL(t) ^2 + 160.86

V3
- Estimated P(t) = 0.427 * EP_RMIP(t)0+ 0.144 * P(t-24) – 0.00724 * NL(t) + 8.78 *10^(-8) * NL(t) ^2 + 151.83

V4
- Estimated M_MIP(t) = 0.272 * M_MIP(t-24) – 0.0000289 * NL(t) + 3.64 *10^(-10) * NL(t) ^2 + 0.44

V5
- Estimated L_MIP(t) = 0.334 * L_MIP(t-24) – 0.0000549 * NL(t) + 7.17 *10^(-10) * NL(t) ^2 + 0.71

V6
- Estimated M_RMIP(t) = 0.255 * M_RMIP(t-24) – 0.0000234 * NL(t) + 2.99 *10^(-10) * NL(t) ^2 + 0.32

V7
- Estimated L_RMIP(t) = 0.398 * L_RMIP(t-24) – 0.0000378* NL(t) + 5.08 *10^(-10) * NL(t) ^2 + 0.4

Figure 0.4: Summary of models obtained using first data set (Case 2)

V1
- $P(t) = 0.99 * \text{Estimated } P(t) - 0.02$

V2
- $P(t) = 0.99 * \text{Estimated } P(t) - 0.025$

V3
- $P(t) = 0.99 * \text{Estimated } P(t) - 0.014$

V4
- $P(t) = \text{Estimated } P(t) - 0.06$

V5
- $P(t) = 1.06 * \text{Estimated } P(t) - 1.29$

V6
- $P(t) = 1.06 * \text{Estimated } P(t) - 1.87$

V7
- $P(t) = 1.1 * \text{Estimated } P(t) - 2.61$

Figure 0.5: Validation of the obtained model with the first data set (Case 2)

V1
- $P(t) = 1.25 * \text{Estimated } P(t) - 8.89$

V2
- $P(t) = 1.41 * \text{Estimated } P(t) - 14.12$

V3
- $P(t) = 1.3 * \text{Estimated } P(t) - 10.08$

V4
- $P(t) = 1.68 * \text{Estimated } P(t) - 22.54$

V5
- $P(t) = 1.89 * \text{Estimated } P(t) - 28.84$

V6
- $P(t) = 1.42 * \text{Estimated } P(t) - 12.6$

V7
- $P(t) = 1.56 * \text{Estimated } P(t) - 16.68$

Figure 0.6: Validation of the obtained model with the second data set (Case 2)

3. Case 3: Week 1 & 3 vs. Week 2 & 4

This section presents results from econometric models of case 3, summarized in Figure 0.7, Figure 0.8, and Figure 0.9 as follows:

V1
- Estimated P(t) = 2.52 * P(t-24) -.00844 * NL(t) + 8.12 *10^(-8) * NL(t) ^2 + 157.52

V2
- Estimated P(t) = 0.158 * EP_MIP(t) + 2.46 * P(t-24) – 0.00847 * NL(t) + 8.07 *10^(-8) * NL(t) ^2 + 154.51

V3
- Estimated P(t) = -2.749 * EP_RMIP(t)0+ 3.413 * P(t-24) – 0.0145 * NL(t) + 1.69 *10^(-7) * NL(t) ^2 + 344.83

V4
- Estimated M_MIP(t) = 0.847 * M_MIP(t-24) - 0.0000366 * NL(t) + 4.34 *10^(-10) * NL(t) ^2 + 0.72

V5
- Estimated L_MIP(t) = 0.526 * L_MIP(t-24) - 0.0000595 * NL(t) + 7.69 *10^(-10) * NL(t) ^2 + 0.89

V6
- Estimated M_RMIP(t) = 1.2 * M_RMIP(t-24) -.0000347 * NL(t) + 3.97 *10^(-10) * NL(t) ^2 + 0.76

V7
- Estimated L_RMIP(t) = 0.764 * L_RMIP(t-24) -.0000461 * NL(t) + 5.79 *10^(-10) * NL(t) ^2 + 0.79

Figure 0.7: Summary of models obtained using first data set (Case 3)

V1
- P(t) = Estimated P(t) - 0.05

V2
- P(t) = Estimated P(t) + 0.03

V3
- P(t) = Estimated P(t) - 0.38

V4
- P(t) = 1.45 * Estimated P(t) - 16.29

V5
- P(t) = 1.76 * Estimated P(t) - 25.68

V6
- P(t) = 1.54* Estimated P(t) - 19.25

V7
- P(t) = 1.79* Estimated P(t) - 26.92

Figure 0.8: Validation of the obtained model with the first data set (Case 3)

V1
- P(t) = 0.15 * Estimated P(t) + 31.74

V2
- P(t) = 0.15 * Estimated P(t) +31.59

V3
- P(t) = 0.11 * Estimated P(t) +33.32

V4
- P(t) = 0.4 * Estimated P(t) + 21.49

V5
- P(t) = 0.80 * Estimated P(t) + 6.58

V6
- P(t) = 0.18 * Estimated P(t) + 31.42

V7
- P(t) = 0.45 * Estimated P(t) + 20.11

Figure 0.9: Validation of the obtained model with the second data set (Case 3)

4. Case 4: Week 2 & 4 vs. Week 1 & 3

This section presents results from econometric models of case 4, summarized in Figure 0.10, Figure 0.11, and Figure 0.12 as follows:

V1	• Estimated P(t) = 0.216 * P(t-24) - 0.00726 * NL(t) + 9.01 *10^(-8) * NL(t) ^2 + 164.78
V2	• Estimated P(t) = 0.441 * EP_MIP(t) + 0.204 * P(t-24) - 0.00692 * NL(t) + 8.24 *10^(-8) * NL(t) ^2 + 146.04
V3	• Estimated P(t) = 0.296* EP_RMIP(t)0+ 0.207 * P(t-24) - 0.00653* NL(t) + 7.9 *10^(-8) * NL(t) ^2 +141.73
V4	• Estimated M_MIP(t) = 0.323* M_MIP(t-24) - 0.000027* NL(t) + 3.34 *10^(-10) * NL(t) ^2 + 0.43
V5	• Estimated L_MIP(t) = 0.373* L_MIP(t-24) - 0.0000518 * NL(t) + 6.61 *10^(-10) * NL(t) ^2 + 0.71
V6	• Estimated M_RMIP(t) = 0.33 * M_RMIP(t-24) - 0.0000198* NL(t) + 2.48 *10^(-10) * NL(t) ^2 + 0.28
V7	• Estimated L_RMIP(t) = 0.407* L_RMIP(t-24) - 0.0000345* NL(t) + 4.52 *10^(-10) * NL(t) ^2 + 0.38

Figure 0.10: Summary of models obtained using first data set (Case 4)

V1	• P(t) = Estimated P(t) - 0.01
V2	• P(t) = Estimated P(t) + 0.03
V3	• P(t) = 0.99* Estimated P(t) -0.31
V4	• P(t) =1.04 * Estimated P(t) - 1.4
V5	• P(t) =1.14 * Estimated P(t) - 4.28
V6	• P(t) = 1.04* Estimated P(t) - 1.42
V7	• P(t) = 1.14 * Estimated P(t) - 4.1

Figure 0.11: Validation of the obtained model with the first data set (Case 4)

V1	• P(t) =1.87* Estimated P(t) -28.28
V2	• P(t) =1.88* Estimated P(t) -28.81
V3	• P(t) = 1.79 * Estimated P(t) -25.55
V4	• P(t) =1.97 * Estimated P(t) -31.89
V5	• P(t) =2.08 * Estimated P(t) -34.67
V6	• P(t) = 1.84* Estimated P(t) -26.82
V7	• P(t) = 1.98* Estimated P(t) -30.72

Figure 0.12: Validation of the obtained model with the second data set (Case 4)

5. Case 5: Week 1 & 4 vs. Week 2 & 3

This section presents results from econometric models of case 5, summarized in Figure 0.13, Figure 0.14, and Figure 0.15 as follows:

V1
- Estimated P(t) = 0.567 * P(t-24) - 0.013 * NL(t) + 1.53 *10^(-7) * NL(t) ^2 + 280.35

V2
- Estimated P(t) = 1.277 * EP_MIP(t) + 0.402 * P(t-24) - 0.0126* NL(t) + 1.38 *10^(-7) * NL(t) ^2 + 237.68

V3
- Estimated P(t) = 0.0597 * EP_RMIP(t)0+ 0.561 * P(t-24) - 0.0129* NL(t) + 1.52 *10^(-7) * NL(t) ^2 + 276.25

V4
- Estimated M_MIP(t) = 0.552 * M_MIP(t-24) - 0.0000379* NL(t) + 4.54 *10^(-10) * NL(t) ^2 + 0.69

V5
- Estimated L_MIP(t) = 0.475 * L_MIP(t-24) - 0.0000634* NL(t) + 7.95 *10^(-10) * NL(t) ^2 + 0.99

V6
- Estimated M_RMIP(t) = 0.51 * M_RMIP(t-24) - 0.0000362* NL(t) + 4.35 *10^(-10) * NL(t) ^2 + 0.65

V7
- Estimated L_RMIP(t) = 0.524 * L_RMIP(t-24) - 0.0000543 * NL(t) + 6.82 *10^(-10) * NL(t) ^2 + 0.83

Figure 0.13: Summary of models obtained using first data set (Case 5)

V1
- P(t) = 1.01 * Estimated P(t) + 0.5

V2
- P(t) = 1.01 * Estimated P(t) + 0.38

V3
- P(t) = 0.99 * Estimated P(t) - 0.5

V4
- P(t) = 1.31 * Estimated P(t) - 10.5

V5
- P(t) = 1.54 * Estimated P(t) - 17.34

V6
- P(t) = 1.25 * Estimated P(t) - 7.72

V7
- P(t) = 1.46 * Estimated P(t) - 13.66

Figure 0.14: Validation of the obtained model with the first data set (Case 5)

V1
- P(t) = 0.5 * Estimated P(t) + 17.6

V2
- P(t) = 0.54 * Estimated P(t) + 16.02

V3
- P(t) = 0.49 * Estimated P(t) + 16.77

V4
- P(t) = 0.66 * Estimated P(t) + 11.64

V5
- P(t) = 0.92 * Estimated P(t) + 3.28

V6
- P(t) = 0.66 * Estimated P(t) + 11.53

V7
- P(t) = 0.84 * Estimated P(t) + 5.36

Figure 0.15: Validation of the obtained model with the second data set (Case 5)

6. Case 6: Week 2 & 3 vs. Week 1 & 4

This section presents results from econometric models of case 6, summarized in Figure 0.16, Figure 0.17, and Figure 0.18 as follows:

V1
- Estimated P(t) = 0.262* P(t-24) - 0.00245* NL(t) + 3.65*10^(-8) * NL(t) ^2 + 59.45

V2
- Estimated P(t) = 0.281* EP_MIP(t) + 0.255 * P(t-24) - 0.0023* NL(t) + 3.24 *10^(-8) * NL(t) ^2 + 49.19

V3
- Estimated P(t) = 0.553* EP_RMIP(t) + 0.253 * P(t-24) - 0.000579* NL(t) + 9.48 *10^(-9) * NL(t) ^2 + 6.8

V4
- Estimated M_MIP(t) = 0.364 * M_MIP(t-24) - 0.0000131 * NL(t) + 1.83 *10^(-10) * NL(t) ^2 + 0.13

V5
- Estimated L_MIP(t) = 0.357 * L_MIP(t-24) - 0.0000348* NL(t) + 4.99 *10^(-10) * NL(t) ^2 + 0.3

V6
- Estimated M_RMIP(t) = 0.413 * M_RMIP(t-24) + 0.00000126 * NL(t) + 1.04 * 10 ^ (-11)* NL(t) ^2 - 0.16

V7
- Estimated L_RMIP(t) = 0.494* L_RMIP(t-24) + 0.94 * 10 ^ (-7) * NL(t) + 5.37 * 10^ (-11) * NL(t) ^2 - 0.38

Figure 0.16: Summary of models obtained using first data set (Case 6)

V1
- P(t) = Estimated P(t) + 0.02

V2
- P(t) = Estimated P(t)

V3
- P(t) = Estimated P(t) + 0.001

V4
- P(t) = 0.98* Estimated P(t) + 1.08

V5
- P(t) = 1.05* Estimated P(t) - 1.28

V6
- P(t) = Estimated P(t) + 0.04

V7
- P(t) = 1.08 * Estimated P(t) - 2.54

Figure 0.17: Validation of the obtained model with the first data set (Case 6)

V1
- P(t) = 1.86* Estimated P(t) -28.23

V2
- P(t) = 1.88* Estimated P(t) -29.38

V3
- P(t) = 1.88 * Estimated P(t) -28.18

V4
- P(t) = 1.74* Estimated P(t) -24.57

V5
- P(t) = 1.75* Estimated P(t) -25

V6
- P(t) = 1.84 * Estimated P(t) -25.73

V7
- P(t) = 1.88 * Estimated P(t) -27.1

Figure 0.18: Validation of the obtained model with the second data set (Case 6)

7. Case 7: the whole 4 weeks

This section presents results from econometric models of case 7, summarized in Figure 0.19 and Figure 0.20 as follows:

V1
- Estimated P(t) = 0.247* P(t-24) - 0.00988 * NL(t) + 1.22*10^(-7) * NL(t) ^2 + 216.15

V2
- Estimated P(t) = 0.917 * EP_MIP(t) + 0.211 * P(t-24) - 0.00926* NL(t) + 1.07 *10^(-7) * NL(t) ^2 + 178.87

V3
- Estimated P(t) = 0.211* EP_RMIP(t)+ 0.24* P(t-24) - 0.00933 * NL(t) + 1.13 *10^(-7) * NL(t) ^2 + 199.18

V4
- Estimated M_MIP(t) = 0.39 * M_MIP(t-24) - 0.0000296 * NL(t) + 3.69 *10^(-10) * NL(t) ^2 + 0.48

V5
- Estimated L_MIP(t) = 0.406 * L_MIP(t-24) - 0.000051* NL(t) + 6.7 *10^(-10) * NL(t) ^2 + 0.67

V6
- Estimated M_RMIP(t) = 0.386 * M_RMIP(t-24) - 0.000022 * NL(t) + 2.81 * 10 ^ (-10) * NL(t) ^2 + 0.33

V7
- Estimated L_RMIP(t) = 0.474 * L_RMIP(t-24) - 0.0000322 * NL(t) + 4.38 * 10 ^ (-10) * NL(t) ^2 + 0.34

Figure 0.19: Summary of models obtained (Case 7)

V1	• P(t) = 1.01* Estimated P(t) + 0.5
V2	• P(t) = 1.01 * Estimated P(t) + 0.38
V3	• P(t) = 0.99* Estimated P(t) - 0.5
V4	• P(t) = 1.31* Estimated P(t) - 10.5
V5	• P(t) = 1.54 * Estimated P(t) - 17.34
V6	• P(t) = 1.25* Estimated P(t) - 7.72
V7	• P(t) = 1.46 * Estimated P(t) - 13.66

Figure 0.20:Validation of the obtained model (Case 7)

APPENDIX E

1. CASE 1 : IN SAMPLE ERRORS

Day (Case 1_in sample)	Daily average error from V1	Daily average error from V2	Daily average error from V3	Daily average error from V4	Daily average error from V5	Daily average error from V6	Daily average error from V7
1	19.48	26.06	18.67	12.40	9.38	9.14	7.09
2	15.18	17.90	14.38	5.75	2.31	5.34	2.67
3	5.10	6.20	4.37	-2.24	-5.00	-3.31	-5.16
4	-18.14	-18.67	-18.77	-14.28	-15.43	-17.05	-17.06
5	-7.88	-4.17	-8.60	1.46	-2.67	-0.93	-2.80
6	8.29	10.63	7.47	14.45	11.82	12.05	12.26
7	2.27	6.36	1.42	3.14	1.43	3.07	2.75
8	11.10	6.34	10.36	0.87	-1.44	2.47	1.43
9	12.66	10.24	11.99	3.07	0.45	0.87	-0.75

2. CASE 1 : OUT SAMPLE ERRORS

Day (Case 1_out sample)	Daily average error from V1	Daily average error from V2	Daily average error from V3	Daily average error from V4	Daily average error from V5	Daily average error from V6	Daily average error from V7
1	-9.20	-3.14	-10.02	-0.44	-1.08	-5.60	-5.47
2	-5.62	-3.04	-6.45	-0.11	-0.65	1.08	2.05
3	-0.41	23.88	-1.27	10.41	9.21	2.72	3.11
4	3.97	9.78	3.15	0.42	-1.84	2.06	1.11
5	0.57	8.52	-0.25	2.46	0.82	0.70	0.12
6	2.42	2.30	1.77	-2.24	-5.30	-5.98	-7.76
7	6.75	4.72	6.02	7.75	5.15	5.28	4.37
8	2.78	15.90	1.92	11.39	9.45	5.87	6.05
9	5.84	25.83	4.91	8.33	6.41	7.14	6.87
10	-5.84	13.50	-6.83	3.82	2.81	2.30	2.42

3. CASE 2 : IN SAMPLE ERRORS

Day (Case 2_in sample)	Daily average error from V1	Daily average error from V2	Daily average error from V3	Daily average error from V4	Daily average error from V5	Daily average error from V6	Daily average error from V7
1	-4.64	-5.60	-5.10	-3.26	-3.98	-3.98	-3.71
2	-1.36	-3.13	-1.62	-2.79	-3.49	-0.88	-0.38
3	2.21	5.43	2.97	7.45	6.25	1.59	1.36
4	4.78	4.21	4.88	-0.62	-2.77	1.78	0.19
5	2.16	1.89	2.19	0.24	-1.23	0.18	-1.01
6	0.89	-0.72	-1.01	-4.49	-6.73	-6.12	-8.27
7	6.42	2.72	2.92	1.96	0.38	1.43	1.08
8	4.45	4.31	3.55	6.83	5.42	3.55	3.50
9	6.65	8.51	7.91	6.06	4.26	5.88	5.09
10	-1.52	0.24	0.47	2.07	0.85	1.73	0.98

4. CASE 2 : OUT SAMPLE ERRORS

Day (Case 2_out sample)	Daily average error from V1	Daily average error from V2	Daily average error from V3	Daily average error from V4	Daily average error from V5	Daily average error from V6	Daily average error from V7
1	17.15	16.79	16.76	9.98	7.48	9.31	6.58
2	12.96	11.93	12.88	4.31	1.45	6.18	2.76
3	3.46	2.07	2.93	-4.10	-6.37	-3.09	-5.55
4	-15.19	-17.11	-17.05	-16.41	-17.41	-17.81	-18.29
5	-5.50	-8.76	-9.02	-6.18	-8.43	-7.48	-7.55
6	8.94	5.72	6.38	7.28	5.71	6.94	7.75
7	3.68	2.23	3.54	0.46	-0.99	1.92	1.12
8	9.10	6.35	8.51	-1.66	-3.56	1.72	0.24
9	9.54	7.52	8.08	0.09	-1.87	0.34	-1.61

5. CASE 3 : IN SAMPLE ERRORS

Day(Case 3_in sample)	Daily average error from V1	Daily average error from V2	Daily average error from V3	Daily average error from V4	Daily average error from V5	Daily average error from V6	Daily average error from V7
1	10.89	10.83	12.86	12.62	9.64	8.93	7.60
2	-1.87	-1.98	-3.90	3.59	2.52	2.48	2.39
3	-5.13	-5.48	-3.21	-2.88	-4.74	-3.89	-4.78
4	-21.09	-21.76	-12.17	-13.41	-15.31	-14.58	-15.89
5	2.16	1.53	4.17	1.99	-1.36	1.10	-0.51
6	20.58	19.37	24.95	2.50	-1.04	8.64	4.52
7	11.87	12.58	8.02	12.99	8.99	6.09	4.21
8	-0.03	-0.25	-2.30	-2.22	-2.44	2.99	1.87
9	2.97	2.73	1.95	2.87	0.76	2.15	0.90

6. CASE 3 : OUT SAMPLE ERRORS

Day(Case 3_out sample)	Daily average error from V1	Daily average error from V2	Daily average error from V3	Daily average error from V4	Daily average error from V5	Daily average error from V6	Daily average error from V7
1	83.32	80.56	122.50	24.82	0.36	66.13	17.65
2	71.92	69.67	100.18	29.49	14.86	44.19	24.72
3	16.51	15.68	19.00	4.52	1.51	7.64	4.69
4	22.58	21.33	30.17	2.78	-1.18	6.21	3.06
5	10.49	9.75	21.48	5.66	1.32	4.36	1.07
6	-16.35	-16.60	-7.69	-2.31	-4.24	-4.10	-6.10
7	44.25	42.34	73.50	18.77	8.85	35.16	18.56
8	26.75	26.24	35.40	17.12	10.63	16.53	10.47

9	26.88	27.02	22.30	8.70	6.14	12.30	8.95
10	2.72	3.03	-11.76	2.03	1.73	0.19	1.50

7. CASE 4 : IN SAMPLE ERRORS

Day (Case 4_in sample)	Daily average error from V1	Daily average error from V2	Daily average error from V3	Daily average error from V4	Daily average error from V5	Daily average error from V6	Daily average error from V7
1	-7.48	-8.07	-7.80	-4.96	-7.87	-5.67	-8.00
2	5.99	4.93	5.89	8.01	6.13	8.03	7.13
3	1.13	0.60	1.86	0.56	-0.77	2.19	0.98
4	6.55	4.50	6.63	-1.45	-3.24	1.86	0.15
5	6.55	4.92	5.78	0.09	-1.77	0.07	-1.92
6	-2.53	-3.89	-3.67	-5.25	-7.30	-6.90	-8.89
7	2.88	0.89	1.71	1.94	0.16	1.60	0.03
8	1.40	2.45	1.89	6.96	5.56	3.90	3.10
9	4.17	6.81	5.92	6.15	4.51	6.30	5.02
10	-3.45	-1.01	-1.15	2.23	1.14	2.20	1.15

8. CASE 4 : OUT SAMPLE ERRORS

Day (Case 4_out sample)	Daily average error from V1	Daily average error from V2	Daily average error from V3	Daily average error from V4	Daily average error from V5	Daily average error from V6	Daily average error from V7
1	13.74	13.67	13.74	9.71	7.43	8.75	6.24
2	9.44	8.60	9.55	3.59	1.02	5.16	2.28
3	0.30	-0.75	0.20	-4.53	-6.59	-3.69	-5.91
4	-17.32	-18.62	-18.02	-16.37	-17.31	-17.58	-18.39
5	-6.50	-6.58	-5.90	-2.70	-3.43	-3.13	-3.55
6	-2.79	-3.44	-1.91	-2.03	-2.78	0.36	-0.10
7	0.50	4.16	1.77	8.07	6.88	2.48	1.62
8	2.17	2.04	2.72	-0.90	-2.82	1.73	0.02
9	-0.26	0.03	0.38	0.30	-1.05	0.31	-1.09

9. CASE 5 : IN SAMPLE ERRORS

Day (Case 5_in sample)	Daily average error from V1	Daily average error from V2	Daily average error from V3	Daily average error from V4	Daily average error from V5	Daily average error from V6	Daily average error from V7
1	19.71	20.88	25.30	11.29	8.27	11.21	7.25
2	13.99	13.41	19.49	4.09	1.45	7.43	3.08

3	4.57	2.86	9.59	-3.48	-5.93	-1.49	-4.99
4	-19.32	-22.54	-14.98	-15.33	-16.61	-16.25	-17.56
5	0.33	-1.76	5.14	-3.29	-5.93	-3.43	-7.00
6	11.13	4.00	16.22	8.98	4.44	10.15	6.17
7	5.12	7.41	10.58	11.10	7.86	7.95	5.70
8	9.06	16.10	14.60	6.96	4.94	8.63	6.31
9	-4.00	4.14	1.61	2.46	1.67	2.00	0.89

10. CASE 5 : OUT SAMPLE ERRORS

Day (Case 5_out sample)	Daily average error from V1	Daily average error from V2	Daily average error from V3	Daily average error from V4	Daily average error from V5	Daily average error from V6	Daily average error from V7
1	3.49	-3.02	7.99	4.90	-3.98	4.08	-2.36
2	16.35	10.29	21.63	16.51	10.47	16.43	12.68
3	4.15	2.37	9.46	2.13	0.08	4.57	2.31
4	14.49	8.62	19.50	0.54	-2.34	4.64	1.44
5	14.30	10.52	19.19	2.97	-0.27	3.63	-0.21
6	-8.57	-9.17	-3.47	-1.43	-2.78	-2.31	-2.98
7	-2.30	-5.43	2.80	-0.88	-2.27	1.76	0.82
8	1.72	11.99	6.97	9.65	7.60	3.43	2.09
9	3.85	4.28	9.15	-1.59	-3.09	3.41	0.85
10	1.01	2.24	6.25	1.24	-0.47	1.87	-0.34

11. CASE 6 : IN SAMPLE ERRORS

Day (Case 6_in sample)	Daily average error from V1	Daily average error from V2	Daily average error from V3	Daily average error from V4	Daily average error from V5	Daily average error from V6	Daily average error from V7
1	-1.84	-2.22	-2.95	-3.38	-6.42	-3.48	-6.14
2	8.79	8.15	7.55	8.78	7.72	8.59	8.57
3	1.59	1.33	1.94	0.44	0.46	1.33	1.17
4	2.12	0.97	1.00	-2.44	-2.53	-0.29	-0.39
5	0.80	-0.07	-2.17	-1.22	-1.00	-2.95	-3.03
6	-3.03	-3.05	-2.48	-1.83	-2.08	-2.32	-2.41
7	0.06	-0.31	1.28	-1.31	-1.65	1.36	1.27
8	0.78	3.20	2.46	8.33	8.07	2.47	2.31
9	0.85	0.86	0.74	-1.57	-1.68	0.08	-0.41
10	-0.41	-0.14	-0.21	0.04	0.12	-0.85	-1.20

12. CASE 6 : OUT SAMPLE ERRORS

Day (Case 6_out sample)	Daily average error from V1	Daily average error from V2	Daily average error from V3	Daily average error from V4	Daily average error from V5	Daily average error from V6	Daily average error from V7
1	8.91	9.02	7.27	8.52	8.57	5.68	5.08
2	4.78	4.39	3.31	1.97	2.11	1.44	0.60
3	-3.27	-3.82	-4.94	-5.67	-5.53	-6.43	-6.98
4	-15.42	-16.22	-17.49	-16.27	-16.17	-17.89	-18.12
5	-5.75	-6.51	-9.44	-6.70	-6.19	-9.89	-10.19
6	4.30	3.09	0.76	1.81	1.65	0.50	-0.09
7	3.70	4.41	3.50	7.40	7.29	3.73	3.86
8	3.91	5.69	6.16	6.01	5.78	5.52	5.33
9	0.16	1.73	3.86	2.75	2.57	2.45	1.74

13. CASE 7 : IN SAMPLE ERRORS

Day (Case 7_in sample)	Daily average error from V1	Daily average error from V2	Daily average error from V3	Daily average error from V4	Daily average error from V5	Daily average error from V6	Daily average error from V7
1	20.74	21.28	16.44	10.16	8.41	9.05	6.86
2	16.35	15.31	12.22	3.81	1.85	5.41	2.68
3	6.43	4.85	2.48	-4.16	-5.71	-3.38	-5.34
4	-14.67	-16.91	-18.61	-16.05	-16.46	-17.33	-17.60
5	-3.65	-4.83	-7.58	-2.26	-5.65	-2.79	-4.82
6	11.67	9.74	7.37	10.67	8.75	10.60	10.39
7	5.46	4.86	1.98	1.00	0.19	2.67	2.05
8	12.51	8.77	8.70	-1.11	-2.50	2.20	0.94
9	13.37	10.58	8.92	0.83	-0.68	0.64	-1.09
10	-4.52	-4.26	-7.93	-2.48	-2.60	-3.04	-2.61
11	-0.93	-1.91	-4.11	-2.02	-2.14	0.51	1.00
12	3.34	11.41	0.40	8.24	7.67	2.37	2.35
13	6.69	6.99	3.09	-1.21	-2.38	1.88	0.70
14	3.72	4.86	0.24	0.48	-0.25	0.47	-0.38
15	3.70	1.51	-0.99	-4.41	-6.01	-6.15	-7.97
16	9.34	5.61	4.30	4.33	2.78	4.12	3.04
17	6.26	8.90	2.43	8.43	7.40	5.14	4.97
18	8.82	14.79	6.05	6.28	5.27	6.72	6.11
19	-1.48	4.05	-3.82	1.82	1.63	1.78	1.57

APPENDIX F

1. CASE 1 : IN SAMPLE ABSOLUTE ERRORS

Day (Case 1_in sample)	Daily average absolute error from V1	Daily average absolute error from V2	Daily average absolute error from V3	Daily average absolute error from V4	Daily average absolute error from V5	Daily average absolute error from V6	Daily average absolute error from V7
1	31.99	36.26	31.82	13.29	9.83	10.09	7.43
2	30.35	29.08	30.26	8.60	6.03	7.71	5.60
3	22.53	21.78	22.64	8.32	8.29	7.17	7.47
4	25.77	31.19	26.10	21.43	21.80	19.99	20.39
5	20.29	26.32	20.57	9.62	8.98	7.62	5.87
6	28.86	34.94	28.99	20.86	17.81	16.84	15.70
7	19.98	27.26	20.05	9.20	8.32	5.86	4.60
8	24.87	26.81	24.84	6.23	5.35	5.26	3.90
9	27.15	24.12	27.13	7.48	5.79	4.97	3.66

2. CASE 1 : OUT SAMPLE ABSOLUTE ERRORS

Day (Case 1_out sample)	Daily average absolute error from V1	Daily average absolute error from V2	Daily average absolute error from V3	Daily average absolute error from V4	Daily average absolute error from V5	Daily average absolute error from V6	Daily average absolute error from V7
1	16.46	22.11	16.85	10.12	9.88	11.28	11.62
2	17.48	19.39	17.93	7.48	7.05	6.42	6.14
3	16.00	39.16	16.40	13.43	12.40	7.51	7.91
4	21.06	24.29	21.24	6.95	7.66	6.43	5.52
5	20.75	26.00	20.81	8.72	7.78	5.46	4.56
6	25.80	26.14	25.92	13.62	12.94	11.77	12.74
7	29.46	30.89	29.57	13.28	10.82	11.16	9.32
8	22.75	38.78	22.74	16.30	14.38	9.01	8.41
9	22.57	34.10	22.45	10.87	9.41	9.17	8.23
10	16.85	29.95	17.05	9.36	8.08	5.36	4.44

3. CASE 2 : IN SAMPLE ABSOLUTE ERRORS

Day (Case 2_in sample)	Daily average absolute error from V1	Daily average absolute error from V2	Daily average absolute error from V3	Daily average absolute error from V4	Daily average absolute error from V5	Daily average absolute error from V6	Daily average absolute error from V7
1	13.18	13.19	12.41	10.49	10.20	10.06	9.76
2	11.51	12.60	11.54	7.90	7.48	6.15	5.60

3	10.41	13.73	10.79	11.52	10.59	7.31	7.55
4	12.76	12.11	12.03	7.07	7.45	6.50	5.79
5	13.14	13.60	12.65	8.73	8.22	6.16	5.05
6	20.11	19.03	17.66	13.46	12.98	11.71	12.41
7	16.98	14.82	14.61	9.33	9.09	7.62	7.30
8	14.27	15.17	12.47	13.95	12.77	8.43	7.88
9	15.01	15.68	14.61	9.89	8.93	8.33	7.11
10	10.51	11.60	10.20	8.53	7.53	6.13	4.95

4. CASE 2 : OUT SAMPLE ABSOLUTE ERRORS

Day (Case 2_out sample)	**Daily average absolute error from V1**	**Daily average absolute error from V2**	**Daily average absolute error from V3**	**Daily average absolute error from V4**	**Daily average absolute error from V5**	**Daily average absolute error from V6**	**Daily average absolute error from V7**
1	22.52	22.13	21.43	11.33	9.06	10.42	7.32
2	20.31	18.82	19.16	7.91	6.21	8.55	6.17
3	15.97	14.74	13.75	9.03	9.26	7.73	7.59
4	22.58	23.65	22.62	22.63	22.75	20.63	20.94
5	10.31	12.05	10.91	10.68	12.97	8.29	8.10
6	18.96	17.42	16.96	14.79	13.54	12.98	12.69
7	13.29	13.45	12.23	9.35	8.75	6.45	5.16
8	16.19	15.56	15.24	6.35	6.28	5.46	4.02
9	17.20	16.16	15.99	7.19	6.06	5.26	3.95

5. CASE 3 : IN SAMPLE ABSOLUTE ERRORS

Day (Case 3_in sample)	**Daily average absolute error from V1**	**Daily average absolute error from V2**	**Daily average absolute error from V3**	**Daily average absolute error from V4**	**Daily average absolute error from V5**	**Daily average absolute error from V6**	**Daily average absolute error from V7**
1	28.17	28.39	36.91	14.57	10.58	12.00	8.30
2	23.14	23.18	31.16	10.38	6.98	9.22	6.15
3	16.67	16.76	30.44	7.87	8.01	7.08	6.97
4	23.19	23.61	34.60	20.17	21.15	18.29	18.89
5	20.13	20.34	34.76	10.12	9.77	7.67	7.88
6	32.45	31.46	46.50	10.41	7.25	15.68	9.26
7	21.93	22.82	33.26	17.04	12.81	9.67	8.17
8	30.03	29.25	41.96	8.25	7.81	12.02	7.43
9	25.25	25.21	36.81	10.51	7.91	8.71	4.75

6. CASE 3 : OUT SAMPLE ABSOLUTE ERRORS

Day (Case 3_out sample)	Daily average absolute error from V1	Daily average absolute error from V2	Daily average absolute error from V3	Daily average absolute error from V4	Daily average absolute error from V5	Daily average absolute error from V6	Daily average absolute error from V7
1	115.76	113.56	163.25	33.80	9.56	74.62	23.50
2	79.80	78.27	113.14	36.96	21.80	47.94	28.14
3	26.50	26.05	37.51	10.81	8.61	11.56	6.49
4	31.61	31.21	40.41	9.30	5.78	9.30	5.61
5	29.18	28.82	39.80	9.12	5.60	9.40	4.94
6	20.16	20.00	30.45	14.45	12.77	14.00	12.31
7	81.54	80.32	111.89	26.92	15.52	44.80	24.66
8	38.64	38.77	57.36	22.24	15.71	18.94	11.76
9	35.44	35.64	48.29	12.24	9.71	15.49	10.62
10	18.41	18.60	33.18	10.36	7.99	5.63	3.85

7. CASE 4 : IN SAMPLE ABSOLUTE ERRORS

Day (Case 4_in sample)	Daily average absolute error from V1	Daily average absolute error from V2	Daily average absolute error from V3	Daily average absolute error from V4	Daily average absolute error from V5	Daily average absolute error from V6	Daily average absolute error from V7
1	9.70	10.86	9.38	9.65	12.67	6.85	8.55
2	16.16	15.66	15.27	14.67	13.14	12.40	11.37
3	11.45	11.99	10.77	9.00	8.37	5.81	4.89
4	14.46	14.21	13.44	6.69	6.34	4.59	3.25
5	15.68	14.64	13.99	7.14	6.43	4.34	4.13
6	18.48	17.33	16.38	13.54	13.35	12.54	13.21
7	13.61	13.21	12.52	8.94	8.60	6.81	6.46
8	12.05	13.04	10.49	13.59	12.46	8.24	7.77
9	12.51	13.73	12.23	9.68	8.73	8.12	6.84
10	10.39	10.75	9.22	8.30	7.43	5.93	5.01

8. CASE 4 : OUT SAMPLE ABSOLUTE ERRORS

Day (Case 4_out sample)	Daily average absolute error from V1	Daily average absolute error from V2	Daily average absolute error from V3	Daily average absolute error from V4	Daily average absolute error from V5	Daily average absolute error from V6	Daily average absolute error from V7
1	19.17	18.95	18.15	10.88	8.95	9.42	6.77
2	16.99	15.62	15.78	7.28	5.98	7.54	5.93
3	14.00	13.52	12.29	9.18	9.38	7.72	7.92
4	23.76	24.18	23.17	22.91	22.99	21.23	21.74

5	13.73	13.34	12.74	10.66	10.43	10.40	10.25
6	12.63	12.62	11.64	8.06	7.65	6.45	5.85
7	10.81	12.80	10.18	11.73	10.70	7.58	7.58
8	11.16	10.58	10.15	6.97	7.37	5.71	5.38
9	12.80	12.69	11.64	8.75	8.28	5.95	5.26

9. CASE 5 : IN SAMPLE ABSOLUTE ERRORS

Day (Case 5_in sample)	Daily average absolute error from V1	Daily average absolute error from V2	Daily average absolute error from V3	Daily average absolute error from V4	Daily average absolute error from V5	Daily average absolute error from V6	Daily average absolute error from V7
1	34.28	36.65	36.17	12.97	9.42	12.69	8.14
2	30.99	31.24	32.58	9.67	6.30	10.88	6.65
3	22.85	23.72	23.28	8.83	8.73	7.61	7.23
4	26.29	29.39	24.53	21.77	22.16	19.75	20.29
5	25.70	25.47	25.44	13.84	12.89	12.27	11.87
6	38.17	34.94	37.34	16.90	12.12	17.58	12.72
7	25.77	32.14	26.67	17.05	14.04	10.99	8.85
8	25.85	31.10	27.57	10.72	9.03	11.28	8.46
9	18.91	22.81	18.01	8.91	7.76	5.87	4.47

10. CASE 5 : OUT SAMPLE ABSOLUTE ERRORS

Day (Case 5_out sample)	Daily average absolute error from V1	Daily average absolute error from V2	Daily average absolute error from V3	Daily average absolute error from V4	Daily average absolute error from V5	Daily average absolute error from V6	Daily average absolute error from V7
1	34.72	32.76	33.24	14.79	9.72	13.18	7.69
2	35.99	35.80	36.62	24.11	17.63	21.48	17.21
3	22.22	25.05	22.93	9.72	8.56	7.98	5.40
4	28.79	29.80	30.32	7.40	5.93	7.84	4.70
5	30.80	27.49	32.06	7.77	5.89	8.54	4.71
6	16.14	18.48	14.76	10.31	10.09	9.27	9.14
7	20.94	22.44	20.00	8.35	7.62	8.38	6.46
8	18.63	32.49	18.54	13.91	11.64	7.81	7.50
9	25.14	24.08	24.76	7.30	7.60	8.16	6.23
10	24.10	26.29	23.89	9.23	8.02	7.43	5.13

11. CASE 6 : IN SAMPLE ABSOLUTE ERRORS

Day (Case 6_in sample)	Daily average absolute error from V1	Daily average absolute error from V2	Daily average absolute error from V3	Daily average absolute error from V4	Daily average absolute error from V5	Daily average absolute error from V6	Daily average absolute error from V7
1	4.96	5.47	5.83	9.04	11.87	5.80	7.15
2	12.73	12.66	11.33	14.80	13.90	11.77	11.71
3	6.43	6.09	4.97	8.45	8.54	4.24	4.18
4	6.78	5.43	3.56	5.53	5.57	3.31	3.25
5	6.95	6.26	3.84	6.42	6.09	4.51	4.56
6	9.60	8.94	8.94	9.92	10.03	9.99	9.72
7	4.72	4.81	4.64	6.92	6.99	5.39	5.53
8	7.19	6.78	7.37	11.59	11.43	8.26	8.22
9	5.10	5.08	5.54	7.57	7.65	5.45	5.15
10	6.17	6.40	4.72	7.97	7.98	5.02	4.92

12. CASE 6 : OUT SAMPLE ABSOLUTE ERRORS

Day (Case 6_out sample)	Daily average absolute error from V1	Daily average absolute error from V2	Daily average absolute error from V3	Daily average absolute error from V4	Daily average absolute error from V5	Daily average absolute error from V6	Daily average absolute error from V7
1	11.10	10.76	7.45	9.57	9.48	5.82	5.50
2	8.45	7.74	5.25	6.12	6.07	4.85	4.83
3	9.30	8.88	8.44	9.17	8.96	8.56	8.45
4	20.25	20.60	20.95	22.37	22.41	21.64	21.68
5	13.99	13.70	13.63	13.85	13.33	14.22	14.08
6	7.66	7.55	5.45	8.34	8.53	5.53	5.76
7	8.40	7.97	6.86	13.25	13.17	7.65	7.50
8	6.95	7.89	6.95	9.11	8.93	6.82	6.67
9	5.87	6.02	6.07	7.64	7.65	5.17	4.51

13. CASE 7 : IN SAMPLE ABSOLUTE ERRORS

Day (Case 7_in sample)	Daily average absolute error from V1	Daily average absolute error from V2	Daily average absolute error from V3	Daily average absolute error from V4	Daily average absolute error from V5	Daily average absolute error from V6	Daily average absolute error from V7
1	28.09	28.26	25.49	11.48	9.34	10.05	7.38
2	25.80	23.33	23.56	7.82	6.06	7.83	5.86
3	19.45	17.64	17.29	8.82	8.76	7.30	7.42
4	23.39	24.36	24.06	22.14	22.25	20.24	20.66
5	15.08	15.76	15.50	8.96	10.62	7.08	6.08

6	24.35	24.35	23.43	18.13	15.56	15.63	14.37
7	16.91	17.36	15.34	9.25	8.51	5.99	4.80
8	21.12	20.16	19.23	6.26	5.76	5.18	3.86
9	22.79	19.68	20.64	7.02	5.90	5.02	3.80
10	14.05	13.49	14.04	10.23	10.04	9.48	9.31
11	13.53	14.69	14.38	7.78	7.30	6.32	5.71
12	12.83	21.96	12.61	12.21	11.36	7.43	7.73
13	17.36	16.83	16.00	6.98	7.54	6.32	5.55
14	16.80	17.85	16.11	8.56	8.00	5.61	4.77
15	23.00	21.28	20.84	13.51	12.84	11.81	12.60
16	23.68	22.20	22.49	11.41	9.71	10.12	8.54
17	18.76	22.07	17.34	14.82	13.55	8.81	8.15
18	19.43	22.22	17.92	9.99	8.95	8.88	7.75
19	13.04	16.42	13.11	8.53	7.68	5.51	4.64