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ENERGOMARKET RULES ACTION PLAN

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EXECUTIVE SUMMARY

This report outlines an action plan for NERC and Energomarket Board for evaluation and revision of any elements of the Energomarket rules and procedures that distort bidding incentives and reduce productive efficiency in the Energomarket This memo identifies various technical aspects of Energomarket rules dealing with bidding, generation scheduling, and settlements which require a comprehensive review for further clarification or revision Two other complimentary in these series consider issues related to Availability Pricing (Capacity Payments) and Ancillary Services Hence, these topics are not treated in this report

The first chapter of this report proposes the creation of permanent Energomarket Technical Committees operating under the direction of the Energomarket Board Energomarket Technical Committees, composed of experts and policy advisors from Energomarket Members, are to engage in systematic evaluation, revision, and addition of Energomarket Rules It is recommended that this report and the other two reports on Availability Pricing and Ancillary Services to be used as discussion material by experts and policy advisors in the proposed Energomarket Technical Committees

The following chapters review various aspects of the Energomarket rules and procedures and identify areas, which either as expressed in the Schedule 2 of the Energomarket Members' Agreement, or in the current practice, require reevaluation, and possibly modification A number of rules and procedures are left undefined and contribute to the non-transparency of the system

Particular attention has been paid to the issues of bidding, commitment, and scheduling Each chapter provides a set of recommendations after the review of the particular subject

Further improvement in the operations of the Energomarket may require a reworking of the organizational relationships between various market supporting institutions However, this report does not consider in detail organizational and political issues that adversely impact proper operation of the Energomarket

UK Pool and UK Pool Rules provided a model for the creation of the Energomarket and development of the Energomarket Rules Hence, the UK Pool Rules and operations in the UK are used as a basis for comparison However, this report does not imply that all operations in Ukraine should follow the UK model It only uses the UK Pool Rules to identify certain aspects

of the Energormarket rules or operations either do not stand on their own or constitute a distorted application of the UK Pool Rules

Recommendations of this report are not meant to imply that the best choice for Ukraine is the entrenchment of the present philosophy of market relations in Ukraine In fact, with most countries experiencing restructuring of their electric power sectors, it is necessary to integrate the lessons learned by the other systems However, in the absence of any real prospect for a complete overhaul of the Energomarket of Ukraine, recommendations of this report are only aimed at correcting shortcomings of the current system

A complete remodeling of the Energomarket with completely different set of rules and procedures, based on a more interactive market electricity providers and electricity customers was not the objective of this investigation

However, it is believed that a careful examination of the present rules and procedures of the Energomarket and the actual practice and the implications on Energomarket reliability efficiency, and transparency, would provide the right basis for significant improvement of the Energomarket of Ukraine It is believed that the best forum for such examination is the proposed Energomarket Technical Committee composed of Ukrainian experts from Energomarket entities

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CHAPTER 1
INTRODUCTION

1 1 OBJECTIVE OF THIS REPORT

1 1 Economically efficient operation of the Energomarket requires proper adherence and compliance with the Energomarket rules and procedures This report identifies various technical aspects of Energomarket rules dealing with bidding, generation scheduling, and settlements which require a comprehensive review for further clarification or revision Issues of Availability Pricing (Capacity Payments) and Ancillary Services are dealt with in separate reports Based on the findings in each chapter, this report outlines an action plan for NERC and Energomarket Board for evaluation and revision of any elements of the Energomarket rules and procedures which distort bidding incentives and reduce productive efficiency in the Energomarket

1 2 To provide a framework for implementation of the proposed action plan, the first chapter of this report proposes the creation of permanent Energomarket Technical Committees operating under the direction of the Energomarket Board Energomarket Technical Committees, composed of experts and policy advisors from Energomarket Members, are to engage in systematic evaluation, revision, and addition of Energomarket Rules

1 3 It is recommended that this report and the other two reports on Availability Pricing and Ancillary Services to be used as discussion material by experts and policy advisors in the proposed Energomarket Technical Committees Numbering system in this report is designed to facilitate discussion in expert groups

1 4 The present memo relies on Pool Rules from England and Wales Pool of Electricity (UK Pool Rules) as a basis for comparison with the Energomarket Rules, principally because the Energomarket of Ukraine was created using the UK Pool as a model However, this memo does not advocate strict adherence to UK Pool Rules

1 5 Ukraine's Energomarket Rules is derived from the UK Pool Rules However, adaptation of UK Pool Rules to Ukraine is neither comprehensive nor consistent The result is lack of transparency and lower economic efficiency in Energomarket operations Furthermore, it is

imperative to check the validity of the premises and assumptions forming the basis for the UK Pool Rules before adaptation to Ukraine Energomarket

1 6 This memo makes the following observations

- Energomarket Rules do not provide any details of the algorithms to be used for determination of Commitment Schedule and Scheduled Generation Full documentation and identical programs should be available to the Energomarket Board UK Pool Rules provide complete and detailed description of the algorithms, and relevant identical programs are operated by both the UK Pool Executive Committee and the UK Grid Operator

- The methodology used for determination of Commitment Schedule (Unconstrained Schedule), appears to be based on heuristics and does not fully account for generation block characteristics Hence, the procedures used at SSA may be sub-optimal The Commitment Schedule should be reviewed in a comprehensive manner and, if necessary, updated, based on widely available mathematical optimization techniques

- The Merit Order Ranking in the Commitment Schedule is based, incorrectly, on *average (standard) cost* of blocks for any given generation level The correct methodology is to use *incremental costs* for any given generation level

- The SMP is calculated, incorrectly, after determination of Generation Schedule accounting for transmission constraints The correct methodology is to calculate SMP after determination of Commitment Schedule (Unconstrained Schedule) ignoring transmission constraints, and before determination of the Constrained Generation Schedule

- The methodology used in the Generation Schedule Program (called V2 in Ukraine) is not documented in the Energomarket Members' Agreement A comprehensive review and full documentation are necessary to ensure optimal determination of Generation Schedule given all the available information

- The methodology used for recovery of Start-Up and No-Load Costs (BSU and BNL), is a simplified version of the methodology used in UK Pool Rules In addition, the basic reasoning of the UK methodology requires reconsideration A new methodology is proposed in this memo

- Energomarket Rules do not specify any methodology for treatment of Automatic Load Shedding (Command Load Curtailment) and for determination of Required Operational Reserve in Energomarket Operations The expected impact is deterioration of actual reliability in system operations, and distortion of market-based valuation of electricity prices

- The rules for flexibility declaration in Ukraine, in the opinion of most experts interviewed, do not properly represent the actual technical and economic constraints of generation blocks A fresh look at requirements and application of flexibility declarations is needed

- It should be noted that the pricing and scheduling methodologies used in other power pools are different from those of UK and Ukraine However, the techniques and methods employed for unit commitment and economic dispatch used in other countries are well documented, the applicability and accuracy or programs used are validated by standard tests, and the operational data produced by those programs are monitored by appropriate supervisory authorities

1.2 KEY TERMS

AP	Availability Price
BNL	Block No Load Cost
BSU	Block Start-Up Cost
COF	Constrained Off
CON	Constrained On
Genco	Generation Company
IES	Independent Electricity Supplier
MFA	Market Funds Administration

Minenergo	Ministry of Fuel and Energy
MOR	Merit Order Ranking
NDC	National Dispatch Center
NERC	National Electricity Regulatory Commission
Oblenergo	Regulated Electricity Supplier
RDC	Regional Dispatch Center
SMP	System Marginal Price
SSA	Settlement System Administration

CHAPTER 2
ENERGOMARKET TECHNICAL COMMITTEE

2.1 NEED FOR ENERGOMARKET TECHNICAL COMMITTEE

2 1 1 This chapter sets out the requirements and procedures for the establishment of a formal Energomarket Technical Committee under the supervision and authority of the Energomarket Board Significant progress has been made in development of the Energomarket of Ukraine, both in technical and organizational terms, which is a unique achievement among the countries of the Former Soviet Union and Eastern Europe However, Energomarket of Ukraine is a dynamic technological and economic entity that needs to evolve further in step with economic development and advances in technology and organization

2 1 2 To ensure the continued success of the Energomarket, and to enhance the effectiveness of the market operations in terms of transparency and efficiency under dynamic conditions, many areas of Energomarket Rules, including pricing, operations, and settlements, should be improved further

2 1 3 In the absence of any formal and normative mechanism for expert review and improvement of Energomarket Rules, the evolution of the Energomarket is subjected to unsound ad hoc decision-making and influence by special interests In order to fulfill the objectives of reliability, economic efficiency, market competition, and balancing the interests of the Energomarket members, the Energomarket of Ukraine requires continuous evolution and adaptation to new conditions in a controlled and systematic manner,

2.2 OBJECTIVES OF THE ENERGOMARKET TECHNICAL COMMITTEE

2 2 1 The Energomarket Board should undertake to establish a formal Energomarket Technical Committee, functioning under the supervision of the Energomarket Board, in order to provide an appropriate setting and a proper forum for systematic expert evaluation, revision, and addition of Energomarket rules and procedures The Energomarket Technical Committee should create a capability and a permanent mechanism for ongoing analysis of Energomarket operations and

development of recommendations for updating of the Energomarket Rules and Procedures, as is the standard practice in power pools of other countries including UK and USA

2 2 2 The Energomarket Technical Committee will function as the technical advisor to the Energomarket Board, and will oversee the activities of any Working Subcommittee organized to address various market issues dealing with pricing, operations, and settlements

2 2 3 The Technical Committee and its Subcommittees should be formed with the direct participation of technical experts and policy advisors employed by Energomarket Members and include representatives from National Electricity Regulatory Commission (NERC), National Dispatch Center (NDC), Settlement System Administration (SSA), and Market Funds Administration (MFA)

2 2 4 The establishment of the Energomarket Technical Committee, as an official venue for the improvement of the evolution of market rules, results in a number of direct benefits, including

- Development of consensus,
- Increased participation by market members,
- Promotion of accountability, transparency, and efficiency,
- Timely adaptation to dynamic market conditions,
- Provision of a mechanism for analysis, development, and adoption of rules based on due process and established procedures, and
- Creation of streamlined decision making process for speedy approval and implementation of recommendations

2.3 IMPLEMENTATION OF ENERGOMARKET TECHNICAL COMMITTEE

2 3 1 The Energomarket Technical Committee should be established under the supervision and authority of the Energomarket Board, consisting of technical experts and policy advisors from Energomarket Members and market supporting organizations

2 3 2 The Energomarket Technical Committee would establish under the direction of the Energomarket Board, a number of Technical Subcommittees, each with specific assignments to review and make recommendations on various technical and organization aspects of the Energomarket rules, procedures, and operations

2 3 3 Each Energomarket Producer and Supplier will assign an employee as a permanent liaison between itself and the Energomarket Technical Committee Each Producer and Supplier will also organize its own internal group of technical experts and policy advisors in order to facilitate communication and cooperation between the Energomarket Members Energomarket Board, and Energomarket Technical Committees

2 3 4 The Energomarket Technical Committee will establish the Working Subcommittees to address the specific issues assigned to it Establishment of Working Subcommittees would be based on the request of the Energomarket Board, or in response to formal written requests submitted to the Energomarket Board by Energomarket Technical Committee, NERC, NDC, any of the Energomarket Members, and upon approval by the Energomarket Board of such requests

2 3 5 The Technical Committee would oversee the works of various Working Subcommittees, vote for adoption or rejection of the findings and recommendations submitted by the Working Subcommittees, and submit its final recommendations for approval to the Energomarket Board

2.4 MEMBERSHIP OF ENERGOMARKET TECHNICAL COMMITTEE

2 4 1 The Energomarket Technical Committee can consist of at least 8 members (4 from Generator Category thermal Gencos and other Energomarket Producers, and 4 from Supplier Category Oblenergos and IESs) The Committee Members will function as technical advisors to the Energomarket Board on Energomarket rules, procedures, and operations

2 4 2 Candidates for membership would be submitted by the Energomarket Members and voted on and appointed by the Energomarket Board

2 4 3 Members of the Energomarket Committee will appointed for staggered 2-year terms One member from the initial membership in each category shall be replaced after one year of service

2 4 4 Members would be elected and appointed at the pleasure of the Energomarket Board Subject to the voting procedures of the Energomarket Board Committee Members can be replaced at will

2 4 5 NDC, SSA, MFA, NERC, and Ukrelectropredacha will participate in the activities of the Energomarket Technical Committees as non-voting members, and provide technical and organizational advice

2 4 6 Each Working Subcommittee will consist of at least 4 members 2 from Generator Category and 2 from Supplier Category

2 4 7 Candidates for membership are to be submitted by the Energomarket Members and voted on and appointed by the Energomarket Board

2 4 8 The Energomarket Technical Committee and each Working Subcommittee may invite outside experts and policy advisors to assist in its activities

2.5 RULES OF THE TECHNICAL COMMITTEE

2 5 1 Typical rules for the functioning of the Energomarket Technical Committee includes

(i) The Energomarket Technical Committee shall meet at least once a month to conduct the business assigned to it by the Energomarket Board

(ii) Attendance by at least one half of membership of Generation and Supplier Category shall constitute a quorum

(iii) The Energomarket Technical Committee shall elect one of its members as the Chairperson based on majority vote

(iv) The Chairperson is responsible to conduct the orderly business of the meetings, to prepare reports of the meetings, to compile the results of the decisions made, and to manage the budget and spending of the Energomarket Technical Committee

(v) Decisions on major recommendations to the Energomarket Board require 2/3 majority of the voting members

2.6 WORKING SUBCOMMITTEES

2 6 1 Each Working Subcommittee will be assigned specific tasks by the Energomarket Technical Committee

- The objective and scope of work to accomplish each task should be fully and clearly defined
- Final and interim deadlines for the accomplishment of the task and its milestones should be identified
- Requirements for monthly written progress reports to the Energomarket Technical Committee should be specified

2 6 2 The Working Subcommittees will report the work progress in person and in writing at least once a month to the Energomarket Technical Committee

2 6 3 The membership of the Working Sub-Committees will work as a team However, dissenting views shall be included in the reports submitted to the Energomarket Technical Committee

2 6 4 The Working Sub-Committee may invite any other outside expert to assist with its work or provide reviews and comments

2 7 PROCEDURES OF WORKING SUBCOMMITTEES

2 7 1 Typical procedures for functioning of Working Subcommittees includes

(i) Each Working Subcommittee will work on a planned schedule on evaluation of Energomarket rules, procedures, and operations, which are within its scope of competence, and develop recommendations for any revisions and additions

(ii) Each Working Subcommittee will collect information and proposals from Energomarket Membership for evaluation and revision of Energomarket rules, procedures, and operations

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(iii) Upon completion of its assigned tasks, each Working Subcommittee shall submit a final report to the Energomarket Technical Committee

(iv) The Final report shall state the task objective, the findings, alternative approaches principal recommendations developed by the majority of participants, and dissenting opinions expressed by the individuals

(v) The Energomarket Technical Committees shall review the final reports and recommendations of the Working Subcommittees, and may request additional presentations, clarifications, and revisions from the Working Subcommittees before issuance of a final report for public distribution for comments

(vi) The Energomarket Technical Committee shall, upon approval by the majority vote in each Voting Category, submit the approved final report and recommendations to the entire Energomarket Membership, through the assigned liaison officers, for review and comments by the Memberships' internal technical experts and policy advisors

(vii) After full review and comment according to defined procedures, final recommendations of the Energomarket Technical Committees are submitted to the Energomarket Board for review, approval

(viii) The Energomarket Board, upon approval, shall submit the final report and recommendations for voting by full membership at Energomarket General Meetings

2.8 BUDGET OF ENERGOMARKET TECHNICAL COMMITTEE

2 8 1 Compensation for the time served by each member of Energomarket Technical Committee and Technical Working Subcommittees will be covered by their original employees The Energomarket Board will not be responsible for salary of the Committee or Subcommittee members

2 8 2 If necessary, Energomarket Board will approve and assign a budget for the operation of the Energomarket Technical Committee and its Working Subcommittees The budget is meant to cover the following items, according to established procedures for expense reporting

- Office space and office utilities, including electricity, telephone, and e-mail services

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- Office equipment including desk-top computer laser printer, and fax machine
- Travel and Meals and Incidental costs of members while traveling on business
- Other approved business related costs of members

2 8 3 The Energomarket Board will determine the annual budget for the operation of the Energomarket Technical Committee and its Working Subcommittees The Energomarket Board will submit the annual budget to the General Membership for approval

2 8 4 Consulting firms may be invited from outside to participate in the activities of the Energomarket Technical Committee or Working Subcommittees subject to competitive procurement of services

2.9 INITIAL ACTIVITY OF THE ENERGOMARKET TECHNICAL COMMITTEE

2 9 1 It is recommended that Four Working Subcommittees under supervision of the Energomarket Technical Committees be organized as soon as possible These are

I Working Subcommittee on Generation Scheduling and Settlements, to review Genco bidding, availability and flexibility declarations, equipment selection dispatch, and Constrained On and Constrained Off payments, and to make recommendations for necessary improvements

II Working Subcommittee on Availability and Capacity Payments, to review the current methodology in light of experience from other countries, and to make recommendations for market stabilizing alternatives

III Working Subcommittee on Ancillary Services, to define different classes of Ancillary Services, to design pricing methodologies, and to create a market in such services

IV Working Subcommittee on Increased Cash Collections in the Wholesale Market, to make recommendations for providing incentives for increasing cash collections and reducing Barter Arrangements in the Energomarket

2 9 2 An interim Energomarket Technical Committee and interim Working Subcommittees can be appointed by the Energomarket Board until formal organizational procedures are developed for dully elected membership

CHAPTER 3
DOCUMENTATION OF COMMITMENT AND SCHEDULING PROGRAMS

3 1 NEED FOR DOCUMENTATION

3 1 1 This memo uses the term *Commitment Schedule* from Schedule 2 of the Energomarket Members' Agreement as being equivalent to the *Unconstrained Schedule* defined by the Schedule 9 of the UK Pool Rules The term *Commitment Schedule* is used interchangeably with *Merit Order Ranking* and *Equipment Identification*, the latter being the term used by the Energomarket Settlement System Administration (SSA) of Ukraine In contrast, the term *Generation Schedule* from Energomarket Rules is taken to be equivalent to *Constrained Schedule* of UK Pool Rules

3 1 2 The Energomarket Rules do not specify the methodologies used for determination of Commitment Schedule (Equipment Identification Procedure), and of Generation Schedule (V2 Program) The end results of these procedures, i e , the Generation Schedule (SG), together with Instructed Generation (IG), are the determinants of the Wholesale Purchase Price (WPP), and hence, have direct impact on level of payments to generation blocks and on the overall wholesale cost of electricity in Ukraine However, due to lack of detailed and documented information on these procedures, Energomarket Board and Energomarket Members are not able to verify proper determination of Commitment and Generation Schedule and the resulting SMP In other words, an independent verification of adherence to Energomarket Rules in Energomarket operations is impossible

3 1 3 In the UK Pool, the Commitment Schedule (Merit Order Ranking/Equipment Identification) is called the Unconstrained Schedule which determines the SMP and the day-ahead Unconstrained Generation (expected generation levels if transmission constraints were ignored) The reason it is called Unconstrained Schedule is because the program ignores any transmission constraints in order to treat all Generating Block price and availability offers fairly without regard for transmission constraints (the application of the fairness doctrine here should be reassessed)

3 1 4 The program used to produce the Unconstrained Schedule, is called the Settlement GOAL Suit, and is run by the UK Pool Settlement System Administration It is exactly identical

to the program used by the Grid Operator (Dispatch) for dispatch scheduling purposes The identical program used by the Grid Operator is called BPS GOAL, except that for actual operation, Grid Operator adjusts the program to take account of the transmission constraints

3 1 5 The UK Pool Rules provide detailed information for the iterative algorithm of the Settlement Goal Based on the information provided, any experienced programmer should be able to produce an equivalent program that will produce the same outputs as the Settlement Goal given all the input data used According to the Appendix 2 of Schedule 9 of the UK Pool Rules all the specifications and documentation of the Settlement GOAL Suit are open and available at the Pool and its Executive Committee (equivalent to Energomarket Board)

3 1 6 Any changes to the Settlement GOAL Suite by the Grid Operator, for any reason, has to be justified and reported to the UK Pool Settlement System Administration and Pool Executive Committee, and major changes have to be approved by the Extraordinary General Meeting of the Pool Members If not approved, no changes shall be made In addition, the UK Pool Executive Committee with the approval of Pool Members, and with advanced notice, may require modifications or replacement of the Settlement GOAL Suite

3 1 7 Due to lack of information on the algorithm of the Commitment Schedule, it is not clear whether the Equipment Identification algorithm used in Ukraine finds an optimal commitment schedule based on the available input data Different studies have concluded that optimal commitment and scheduling would save nearly 5% to 10% of the annual fuel costs (about $300 million or more in annual savings in Ukraine) The potential savings, more than justify upgrading of the software and hardware necessary for optimal commitment, scheduling, and economic dispatch

3 1 8 It is not clear how the values of Automatic Load Shedding (or Command Load Curtailment) are accounted for in the determination of day-ahead demand If expected unmet demand is included in total demand, then day-ahead generation scheduling should indicate shortfalls in meeting day-ahead demand These demand shortfalls will constitute the amount of Automatic Load Shedding to be expected, and in addition, also provide the correct value for determination of "operating reserve shortfalls" to be used in calculation of Availability Pricing Hence, further clarifications are required This subject will be treated more fully in the next memo in this series

3 1 9 A related issue is the determination of Required Operating Reserve (and other definitions of Reserve) There appears to be no systematic methodology defined by Energomarket Rules to determine Reserve Requirements and to properly include these in calculation of Commitment Schedule and Scheduled Generation

3.2 RECOMMENDATIONS

3 2 1 Energomarket should, in cooperation with NDC, accomplish the following

- Provide full documentation for Commitment Schedule Program, including full description of the algorithm and program steps for determination of Commitment Schedule and the resulting SMP

- If necessary, modify the Commitment Schedule Program based on mathematical programming principles, to ensure optimality based on all available information

- Amend the Energomarket Rules to include full documentation on Commitment Schedule, and guidelines to be followed by SSA and Energomarket Board for running of the program, for making changes to the program, and for communication and dissemination of Commitment and Generation Schedule information to interested parties

- Define and document the procedures for setting values of Automatic Load Shedding and for Required Operating Reserve, and to account for Automatic Load Shedding and Required Operating Reserve in the Commitment Schedule and Scheduled Generation

CHAPTER 4
COMMITMENT SCHEDULE AND MERIT ORDER RANKING

4.1 INCONSISTENCIES IN COMMITMENT SCHEDULE

4 1 1 Initial ranking of blocks in Ukraine for the next day's peak hour is based only on the consideration of No Load and Average Cost of blocks (called Standard Cost by SSA) operating at any given generation level Start-Up costs and other operational characteristics are taken into account heuristically at later stages to determine block commitments for other hours of the next day Major variables ignored are Block Minimum Rundown and Minimum Run-Up Rates of generation blocks

4 1 2 The iterative algorithm in UK, described fully in the UK Pool Rules, directly takes into account all associated costs of generation, including Start-Up, No-Load, and all Incremental Costs In addition, the algorithm allows for full consideration of all operational characteristics of generation units, including Minimum On Time, Minimum Off Time, Minimum Rundown Rate, and Minimum Run-Up Rate

4 1 3 Merit Order Ranking based on Average Costs of blocks results in a Commitment Schedule which minimizes (if optimal procedures are used) the total operational (fuel and O&M) costs of generation across the whole system However, minimizing the total average cost of generation experienced by Gencos, is not the same as minimizing the total payments to the Gencos For instance, it is possible to have two different generation blocks, where one block has a higher average cost and a lower incremental cost compared to the other block for the same loading point Merit Order Ranking should be based on minimization of total expected payments to generation blocks, not on minimization of average costs of generation blocks Therefore, any improvement will result in tangible savings to the power sector

4 1 4 To clarify the issue of costs this subsection provides a description of incremental prices used in (i) price offers in UK Pool, (ii) price offers in Ukraine Energomarket, (iii) prices used in determination of Commitment Schedule It should be noted that the Energomarket Members' Agreement and NERC Licenses specify that the bidding by Gencos should be based on actual costs A great deal of good work has been done in the initial stages for the development of the bidding procedures Further evaluation is now necessary to ensure that the price bid setting

methodology used by the Gencos is consistent with the procedures used for evaluation of costs in the Generation Scheduling

4 1 5 UK Pool In UK Pool, price offers are not required to be cost-based However, it is argued that under generation competition, Incremental Price Offers would be based on actual marginal costs of generation Price offers in UK Pool include Start-Up (price per instance) No-Load (price per hour), and one to three Incremental Prices (price per additional MWh) The first incremental price is the price of an additional MWh for a generation range starting at 0 MW The Second Incremental price is price of an additional MWh for a generation range starting at Elbow Point 1 (MW) The Third Incremental Price is the price of an additional MWh for a generation range starting at Elbow Point 2 (MW) and extending to the maximum load of the generation unit These are referred to as "Piece-Wise Linear Willans Line"

4 1 6 Ukraine Energomarket Instructions provided to Gencos in Ukraine (Jim Galambas method, as reported in his memo of 10 October 1996), set the incremental price at the higher elbow point as the average incremental fuel cost values between each pair of elbow In other words, the value calculated for point ***k,*** is the average incremental fuel cost for the incremental loading between ***k-1*** and ***k*** The incremental cost determined is actually equal to the marginal cost of an intervening point between ***k-1*** and ***k*** The location of the intervening point depends on the shape of the cost curve

4 1 7 Commitment Schedule The Energomarket Commitment Schedule Program (Roger Vernon method, as reported in the Galambas memo), assumes that the incremental cost reported for point ***k*** is the average incremental cost for incremental loading from point ***1*** to point ***k*** (point ***1*** is at the Minimum Stable Load) This method provides a less accurate approximation of the marginal cost at point ***k*** compared to the Galambas method, since the value reported is for an intervening point between points ***1*** and ***k*** (it is basically identical to average fuel costs excluding start-up and no-load costs) The use of the Roger Vernon method was confirmed in interviews with Mr Yalovoy, the SSA expert

4 1 8 Therefore, the Energomarket Scheduling Program would evaluate total fuel cost values for each block based on incorrect premise concerning the meaning of the incremental cost In other words, the program uses the wrong data to determine the optimal schedule, or to put it another way, the resulting schedule cannot be optimal in the sense that it cannot result in the minimum total system operating costs

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4 2 RECOMMENDATIONS

4 2 1 It is recommended that the relevant Working Subcommittee of the Energomarket Technical Committee should take the following actions

- Modify the Commitment Schedule Program to account for all generation characteristics including BSU, BNL, and all INC costs, in addition to MOT and MOF, and Minimum Rundown and Minimum Run-Up Rates of Blocks

- Modify the Commitment Schedule Program to base the Merit Rank Order on Incremental Costs instead of Average Costs (Standard Costs)

- Using the iterative UK methodology as a model, an experienced mathematical programmer should be able to develop, write, and validate an in-house program in one to two months

CHAPTER 5
SMP, AP, AND CONSTRAINED ON AND OFF PAYMENTS

5.1 CALCULATION OF SMP, AP, AND CON AND COF PAYMENTS

5 1 1 SMP in Ukraine is determined after *Constrained Generation Schedule* is calculated Proper application of UK type Pool Rules requires determination of SMP based on *Unconstrained Generation Schedule* (after Equipment Identification, but before running the V2 Program) This provides a justification for Constrained On (CON) and Constrained Off (COF) payments, because, in actual operations, transmission constraints and reliability considerations result in some units being Constrained On and some being Constrained Off However, as indicated, the value of SMP in UK methodology is not similar to the value of SMP in Ukraine methodology Hence, the whole basis for CON and COF payments in Ukraine is unclear

5 1 2 Even if the proper methodology is not used, it is still possible to have Constrained On and Constrained Off Blocks due to errors in day-ahead demand forecast or other constraints which become known in real time Most of these additional costs to the system are due to "bad" scheduling These are avoidable if better software and data are used for scheduling In some instances, other unpredictable technical constraints may result in Constrained On or Off payments, which would be unavoidable However, whatever the reasons for deviation between actual and scheduled generation, the payments to Constrained On and Off Blocks are not actually implemented in Ukraine

5 1 3 A major problem with the UK methodology is that Gencos which have a dominant market position in isolated transmission islands, may use the transmission capacity availability information, and expectation of being Constrained On or Off, to bid prices that will directly benefit them This may be a non-issue at this point, because it is unclear whether any blocks are compensated for being Constrained On or Off However, when and if implemented, procedures should be put in place to prevent gaming by Gencos

5 1 4 Another major shortcoming of the Energomarket Operations in Ukraine, is the absence of an official Dispatch Log or Journal In the absence of a Dispatch Log, it becomes impossible to independently verify the reasons for deviation of IG from SG, and to calculate CON, COF, and Penalty payments to generation blocks

5 1 5 Formulas provided in the Schedule 2 of the Energomarket Members Agreement for calculation of CON and COF payments are based on "opportunity value of lost revenues All the formulas, except the last formula in Section 8 3, can be derived based on this principle The last formula, however, seems to need a slight modification Derivation of all formulas will be provided at a later date as Appendix D to this memo

5 1 6 Although the UK Pool Rules for CON and COF payments are used as the basis for CON and COF payments in Ukraine, a fundamental question is whether it is necessary to determine SMP based on Unconstrained Schedule and pay compensations for generation blocks affected by transmission constraints A more sophisticated reasoning and approach, with proper incentives may prove more suitable to Ukraine Question to address is whether power plants placed on constrained areas due to bad planning should be compensated

5 1 7 In the absence of price caps on SMP, a natural limit on SMP is the Value of Unserved Energy (Value of Lost Load in UK, and Fixed Cost Factor (FCF) of Schedule 2 in Ukraine) If SMP is greater than FCF, then a rational customer will prefer to go without electricity than pay a higher price than the value of lost load Hence, market rules should set an upper threshold on SMP

$$SMP \leq FCF$$

5 1 8 A separate report will provide a detailed review of the Availability Pricing methodologies, and present alternative approaches Here we point at a required correction for the present methodology The Fixed Cost Factor (FCF) in all formulas of Schedule 2 should be replaced with (FCF-SMP) in order to avoid double payment of SMP Theoretical formulation of Wholesale Purchase Price (WPP) is based on probabilistic expectation, dependent on the value of Loss of Load Probability (LOLP), or

$$WPP = ((1 - LOLP) \times SMP) + (LOLP \times FCF)$$

Where LOLP is represented by an algebraic substitute based on operating reserve margin defined in Section 5 5 2 of the Schedule 2 Simplifying the above expression we get

$$WPP = SMP + LOLP \times (FCF - SMP)$$

5.2 RECOMMENDATIONS

5 2 1 It is proposed that the relevant Working Subcommittee of the Energomarket Technical Committee should take the following actions

- Modify the Energomarket Rules so that SMP is determined based on Unconstrained Schedule instead of Constrained Generation Schedule
- Check the last formula in Section 8 3 of Schedule 2 of the Energomarket Members' Agreement, which appears to be incorrect, and make the necessary corrections
- Develop and implement the Dispatch Log/Journal as soon as possible to enable CON and COF payments to Constrained On and Constrained Off generation blocks
- For future improvements, investigate the rules and procedures, and justifications, for Constrained On and Constrained Off payments to blocks in Ukraine, and consider other alternatives
- Amend the Market Rules to reflect the correct upper threshold on SMP, which is FCF
- Substitute (FCF-SMP) in place of FCF in all formulas of the Schedule 2

CHAPTER 6
GENERATION SCHEDULING PROGRAM

6.1 PROBLEMS WITH THE GENERATION SCHEDULING PROGRAM

6 1 1 In US Power Pools, a multi-period (daily and weekly) optimization requires utilization of a Unit Commitment Program The program takes as input start-up costs (BSU), the no-load costs (BNL), the short-run marginal costs (SRMC or its piece-wise linear representation, INC), and generation and transmission constraints, and determines an optimal commitment schedule (schedule of start-ups and operation) Then at each instant in time (real time or hourly) an Economic Dispatch Program finds the best operating points of the already committed units, and determines the locational and system marginal cost corresponding to the SRMC of the marginal block, subject to generation and transmission constraints and network losses

6 1 2 The V2 Program, reportedly employed in Ukraine, has been represented as a pared-down Economic Dispatch Program used for day-ahead multi-zonal generation scheduling, but lacking in capability for multi-period commitment optimization It is not clear whether the V2 Program is a parallel flow model (suitable for electrical networks based on Kirchhoff's laws) or transportation model (linear approximation of electrical network as any other transportation network), although it is reported that V2 accounts properly for nonlinear network losses The program is also limited in its capability to handle large-scale problems and requires some aggregation of blocks to reduce the size of the optimization problem for computational reasons The V2 program was designed mainly to simulate system operations with emphasis on thermal power plants NPPs and CHPs are treated as must-run units HPPs are treated using a separate program, but are used for peak shaving (one impact being lowering the cost to customers at peak periods relative to off-peak periods)

6 1 3 SMP in Ukraine is calculated after the Scheduled Generation (SG) is determined, presumably reflecting the network constraints Therefore a single SMP encompassing a number of zones and natural market areas (areas enclosed by fully loaded transmission lines) is not consistent with economic principles justifying marginal cost pricing, and has the effect of increasing the effective price of electricity If marginal price is to be determined after consideration of network constraints, then a better choice is a number of zonal marginal prices instead of one system-wide marginal price (which is the maximum of all the zonal marginal

prices) If there were no transmission constraints causing multiple natural market areas then a single SMP would suffice, but transmission constraints do exist in Ukraine and a system-wide SMP for electricity is similar to pricing any commodity at a single value across the whole country

6 1 4 The Generation Scheduling Program (V2) does not appear to be used properly and it may not be producing the optimal schedule The main reason is that the program first determines the Scheduled Generation (SG) based on some objective cost function, and then based on SG it determines the Block Settlement Price (including Block Fixed Heat Charge, BFHC), and consequently, the System Marginal Price (SMP) This implies that the prices used for optimization of system operation (forming the objective function) are different from the prices that are determined based on the results of the program (the chicken or egg problem)

6 1 5 Energomarket Rules do not provide any guidelines on dispatching and settlements of CHP plants The issue is complex because CHPs can operate in two zones must-run for heat production, and adjustable condensing generation Separation of heat and electricity based costs and applied tariffs complicate the picture further

6 1 6 In the long run, to ensure real economic efficiency and to properly apply the Energomarket Rules, it may be necessary to do a complete overhaul of the Generation Scheduling Program The improvements would include installation of

(i) A fully specified and tested Unit Commitment Program for multi-period (weekly and day-ahead) commitments, and

(ii) An Economic Dispatch Program for real-time (or hour-ahead) dispatching

6 2 RECOMMENDATIONS

6 2 1 It is recommended that the relevant Working Subcommittee of the Energomarket Technical Committee should take the following actions

- Fully document the algorithm and the procedures used for Scheduled Generation (V2 Program) It is suggested that the following points related to Generation Scheduling be investigated

  - Mathematical structure of the Optimization Algorithm

- Form of the "Objective Function" being optimized (or minimized)
- Treatment of Transmission Constraints
- Treatment of Network Losses
- Treatment of Required Reserves
- Data Inputs to the program
- Treatment of Generation Constraints
- Consideration multi-period attributes Start-Up Costs, No Load Costs, and Minimum On and Off Times (part of Merit Order Ranking or Unit Commitment Program but not of Economic Dispatch)
- Energy-limit constraints (limited fuel for TPP)
- Treatment of NPP
- Treatment of HPP and (limited storage for HPP)
- Treatment of CHP (two-mode operations)

▸ Resolve possible inconsistencies in generation commitment and scheduling procedures For instance, Scheduled Generation is based on minimizing system operational costs calculated based on generation bids, but prices to be paid to generation are set after the V2 program is run

▸ Evaluate possibility of having Zonal Marginal Prices based on different SMP for different control or market areas in Ukraine, taking into account the transmission constraints

- A single SMP for the whole country makes sense for a small country with no serious transmission constraints For a big country like Ukraine, which is larger than most European countries, it would make more economic sense to

have different SMP for different regions One impact will be lower electricity costs

- Implementation of the concept is not difficult, because a Constrained Generation Program finding the optimal generation mix for each hour, can also determines the hourly marginal costs for each constrained area which can form the basis for hourly Zonal Marginal Prices

- Document the procedures for specification of Instructed Generation (Result of real-time considerations) Identify conditions under which Instructed Generation is different from Scheduled Generation, and how the differences are justified

- Identify conditions under which Actual Dispatch differs from Instructed Generation, and specify where penalties would apply These last two items can be part of the specification for the development of a Dispatch Log

CHAPTER 7
ALTERNATIVE APPROACHES TO SCHEDULING

7.1 EXAMPLE

7 1 1 Alternative methodologies to be considered in the future for cost-based bidding and marginal cost based pricing should be based on the following principles

- Under optimal operations a thermal unit will operate at a loading point (MW) where its marginal operating cost is equal to the market price for energy This is the point of maximum profit (when marginal cost equals marginal revenue) This is the principal reason for marginal cost pricing Market economists argue that marginal cost pricing promotes economic efficiency and optimizes the "social welfare function"

- Some units with operating costs rates far below the market price will operate at their maximum load These are the base-load units and will recover above their average operating costs (provided BSU and BNL are also recovered fully based on the recommendations of the following section) These units may or may not recover their full fixed costs, depending on the how high the SMP is

- Some units with operating costs rates far above the market price will not operate, unless constrained to be on by the system operator These units will recover below their operating costs If they are Constrained On units, they will recover through Constrained On payments Similarly, if a plant is inflexible, its costs can exceed the SMP and it therefore will lose money as it operates

- Marginal units have operating costs rates close to the market price These units may adjust their load up or down until their marginal cost match the market price These are peaking or load following units These units will recover their average fuel costs, if BSU and BNL costs are fully recovered However, the difference between the SMP and their average fuel cost may not be great enough to recover their fixed costs fully These are the units which definitely need some form of capacity payment in addition to SMP based energy payments

- When SMP is determined using incorrect data or based on imperfect Generation Scheduling Program, the marginal block which may not necessarily want to operate at the loading point assigned to it by the scheduling program, if the SMP set is not based on the block's marginal cost It will change its loading to a point where its new marginal cost matches the SMP determined by the Energomarket

7 1 2 Therefore, if market prices are in fact based on marginal fuel costs, each block, acting independently from other blocks, will have an incentive to report its actual marginal costs provided that safeguards are in place to prevent gaming by Gencos If the block reports a number less than its actual costs in order to ensure dispatch, then it runs the risk of being the marginal operating unit and setting the SMP, and hence under-recovering its variable costs If the block reports a number greater than its actual costs, then it runs the risk of losing to competition and not getting dispatched at all As the section on commitment costs also points out, for the concept of cost-based bidding, economic dispatch, and marginal cost pricing, to work properly, then the BSU and BNL costs should not be directly included in SMP

7.2 RECOMMENDATIONS

7 2 1 It is proposed that the relevant Working Subcommittee of the Energomarket Technical Committee should take the following actions

- Consider alternative methodologies for accurate accounting of system operational costs based on cost-based bidding and marginal cost pricing and separate recovery of BSU and BNL costs, employing optimal unit commitment and economic dispatch programs

CHAPTER 8
BLOCK START-UP AND BLOCK NO LOAD COSTS

8.1 ACCOUNTING FOR BLOCK START-UP AND BLOCK NO-LOAD COSTS

8 1 1 Initial procedures for inclusion of BSU and BNL and SMP were based on current methodologies used in UK However, to further correct the price signals, impact of the inclusion of BSU and BNL in SMP in the form specified by the Agreement should be investigated The main reason is that they make the prices during QSP (Qualifying Settlement Periods currently set to start at 6 00 a m and end at 11 00 p m) higher than they should be BSU and BNL are relevant only when considering multi-period unit commitment (Equipment Identification) decisions If no economic justifications are found for payments of commitment costs to Generators only during the QSP, then an improved methodology should be developed

8 1 2 The UK Pool Rules divide each day's Settlement Periods into two sets of Table A Periods and Table B Periods Table A Periods represent the Peak periods, and Table B Periods represent the Trough periods of the day Start-Up and No-Load costs are only recovered during Table A Periods Table A Periods in UK Pool Rules correspond to the QSP in Ukraine However, since Peak and Trough periods change from day to day, so do Table A and Table B periods UK Pool Rules provide detailed procedures to determine Table A and Table B periods from day to day Hence, UK Pool Rules, in contrast to Energomarket Rules, provide a more accurate representation of the day to day variability of the peak and off-peak periods that provide a better (if not complete) justification for recovery of Start-Up and No-Load Costs at Peak periods

8 1 3 Memos by Jim Stanfield (23 July 1997) and Jorge Karacsonyi (27 July 1997) have previously recommended modification of the methodology for recovering of start-up and no-load costs Their recommendations are in line with Hagler Bailly recommendations in Russia for separate treatment of commitment costs which include start-up and no load costs Relevant issues to consider include

- Optimal operations require accounting for these costs in Unit Commitments done for a multi-period time horizon (e g , weekly or daily) As stated before, it is not clear whether a multi-period unit commitment program is being used or that these

costs are actually considered in any manner other than the Merit Order Ranking for commitment scheduling of blocks

- Inclusion of the BSU and BNL costs in Settlement Bid Price (SBP) and subsequently in SMP, distorts the actual marginal cost of system operations The real SMP should only include the INC component of costs (if INC is based on short-run marginal cost or SRMC), with separate accounting for BSU and BNL The probable reason BSU and BNL were in included in the SMP in UK, was to make settlement calculations easier, and provide more incentives for reduction in load during peak hours Both of these premises are contestable A similar but simpler procedure was applied in Ukraine

- Inclusion of BSU and BNL in SMP in the form specified by the Agreement distorts the price signal by making the prices during QSP higher than they should be As indicated before, self-dispatching blocks would want to change their loading point where their marginal costs match the market price they would face Under optimal (minimum cost) operations, most flexible blocks in each natural market area will operate at the same short-run marginal cost (SRMC) loading point This system-wide SRMC, adjusted for location-dependent losses and line constraints, is called *system lambda*, and is usually the output of the economic dispatch programs used in electric power system control centers in the US However, for some blocks the system lambda will be either higher or lower than their SRMC at any loading point of their operating range These blocks will be operating at their maximum or minimum loads At each instant in time, BSU and BNL for loaded blocks are considered as sunk cost BSU and BNL are relevant only when considering multi-period unit commitment decisions For these and other reasons, economists would attest that distorted prices ultimately result in inefficient allocation of resources

- Similarly, all the operating blocks will be paid a no-load cost based on the no-load cost of the marginal block However, this payment has no relation to their own no-load costs, or the number of hours they would be running during the day

- There must be a distinction between commitment payments (BSU and BNL) to the Energomarket Producers (generators) and recovery of these costs from the Energomarket Customers There is no economic justification for payments of commitment costs to Market Producers only during the QSP However, one can argue that these costs reflect commitment of units to meet the peak load of each

day, hence, payments by Market Customers for these costs should reflect their contribution to the daily or weekly peak load (whatever the commitment time horizon), which generally happens during the QSP These two interrelated issues i e , timing of payments for commitment costs to generators, and timing of recovery of these costs from customers, may have gotten confused in UK, and similarly in Ukraine

8 1 4 Hourly data on start-up (BSI), Scheduled Generation (SG), Instructed Generation (IG), and Actual Generation (AG) exist at NDC and SSA Therefore, exact assignment of individual BSU and BNL costs to each block based on these operational data for each settlement periods should not by any more complicated than using the formula given in Schedule 2 The benefits are

- There will be correct accounting and payments for these costs,
- Each blocks will get compensated for actual commitment costs,
- Price signals will not be distorted, and
- Correct numbers will be used for bidding, scheduling, and settlements

8.2 RECOMMENDATIONS

8 2 1 It is recommended that the relevant Working Subcommittee of the Energomarket Technical Committee should take the following actions

- Evaluate the impact of the current procedures on system operational costs
- If warranted, develop a simple methodology where actual BSU and BNL costs are recovered by each block in an unbundled form separately from SMP
- A simple methodology can be developed where actual BSU and BNL costs are recovered by each block based on the following principles
  - Use a Unit Commitment Program (or even the current methodology in Ukraine) to do a multi-period (e g , weekly or daily) minimum cost scheduling of blocks accounting for each blocks bids for BSU, BNL, and INC

- For blocks that follow the commitment schedule (dispatch order) pay their start-up costs for each actual instance they are started up (use BSI) The impact on hourly prices should not be significant, although this needs to be investigated

- For blocks which follow the commitment schedule (dispatch order), pay their no-load costs for all the periods when they are on (use SG or IG or AG)

- At each instant in time, for "committed" blocks, use an Economic Dispatch Program (or even the current methodology in Ukraine) to do economic dispatch of blocks running The program would also determine the system lambda and hence, the optimum loading point of each block, and the locational marginal cost (SRMC of the marginal block) This cost sets the SMP

- At each billing period for the customer (daily in Ukraine), the total commitment costs (BSU and BNL) paid to Market Produces (Gencos) are evaluated and recovered from the Market Customers A recommended method is to prorate total commitment costs paid to Gencos by each customer's peak consumption during the billing period Justification is that unit commitments are driven by the need to meet the weekly or daily peak demand at minimum cost

- Acceptable approximations to the above methodology, tailored to the current capabilities at NDC and SSA, are possible It is important to note that current available data should make adoption of this methodology possible Adoption of more sophisticated unit commitment and economic dispatch programs are not necessary for cost allocation purposes

CHAPTER 9
FLEXIBILITY DECLARATIONS

9.1 FLEXIBILITY AND IMPACT ON PRICES

9 1 1 Energomarket Rules indicate that only the blocks that meet the tight flexibility criteria can set the SMP Thermal power plants designed during the times of the Former Soviet Union are inherently inflexible The practical result is that only few blocks actually compete to set the SMP during QSP, which does not constitute real competition, and does not promote market efficiency in keeping prices low

9 1 2 The criteria used in the Agreement sometimes results in all blocks being labeled as inflexible at non-QSP, resulting in zero SMP Because of the narrow range of flexibility criteria, more expensive blocks, even when dispatched, do not set the SMP, and hence, are faced with market prices which do not even recover their variable costs This would provide an incentive for declaring those blocks as unavailable Hence, the current pattern of flexibility declarations does not support the contention that the current methodology provides an incentive for blocks to be more flexible

9 1 3 If BSU and BNL costs are recovered during nighttime, then Energomarket would pay for any start-up at nighttime (which is not the case now) This is one more reason to separate BSU and BNL from SMP set by flexible blocks only It is odd only BSU and BNL of flexible blocks gets into the calculations

9.2 RECOMMENDATIONS

9 2 1 It is proposed that the relevant Working Subcommittee of the Energomarket Technical Committee should take the following actions

- Check the flexibility criteria and investigate its implications for competition and setting of SMP

- Develop recommendations for improvement of the methodology and elimination of any shortcomings in present procedures

- Recommendations should consider the suggestions provided in the in the memo by Jorge Karacsonyi (27 June 1997), which basically argues that a block should be treated as inflexible only when it is dispatched at a load higher than optimal due to technical problems Technical problems refer to inflexibility in operations within the "nominal" parameters specified by the manufacturer These technical problems can be overcome by proper maintenance

- One alternative is to extend flexibility rules to non-QSP hours, and provide incentive payments for declaring blocks as flexible

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CHAPTER 10
GRID CODE

10.1 NEED FOR A NEW GRID CODE

10 1 Ukraine needs a "new" Grid Code to bring together all the technical requirements for the reliable operation of the electricity network A new Grid Code will complement the Market Agreement and the Energomarket Rules

10.2 RECOMMENDATIONS

10 2 1 It is proposed that the relevant Working Subcommittee of the Energomarket Technical Committee should take the following actions

- Document the current procedures used in Ukraine
- Use the current procedures, in addition to Grid Code documents from other countries, to develop a new Grid Code for Ukraine

APPENDIX A
REVIEW OF ENERGOMARKET MERIT ORDER RANKING

A1 This appendix presents an overview of the Merit Order Ranking (MOR) procedures used by the Settlement System Administration (SSA) in Ukraine The objective is to present the materials of this appendix and the next to Energomarket experts and operational personnel, in order to check the accuracy of the statements, and if required to revise them

A2 The understanding of the present practice presented here reflects the results of separate meetings held with Mr Alexander Yalovoy, Leading Engineer of SSA (21 April 1998), and Paul Davis of Coopers & Lybrand and Roger Vernon of Mott MacDonalds (23 April 1998)

A3 Merit Order Ranking in Ukraine is more commonly referred to "Identification or Selection of Equipment" by the Ukrainian experts It is somehow a more simplified version of "Unit Commitment" methodology applied on a daily basis MOR selects a set of equipment (blocks) that should be in operation for the next schedule day in order to meet the maximum day-ahead demand It is reported that MOR is not a complex procedure and can actually be done manually on a spreadsheet

A4 The maximum day-ahead demand is the forecast value of demand, which does not include operating reserve requirements Currently, the evaluation of "optimum operating reserve" is a difficult task requiring a lot of data and sophisticated probabilistic analysis The initial methodology for MOR was developed by Mr Potiakin of Systems Settlements Administration, together with the consultants from Ewbanks Pierce McDonald and Coopers & Lybrand It was initially a spreadsheet program but was later written in Visual C++

A5 SSA provides Regional Dispatch Centers (RDC) and their sub units with a desired range of reserve values between 400 to 800 MW The Senior Dispatcher in each RDC is actually the person who decides what the best number is depending on the conditions of the day Blocks are ranked for MOR based on their INC and BNL costs, but Spinning Reserve is not accounted for Instead, some allowance is made for reserve based on total potential of blocks and actual schedule Therefore, considerations for reserve are made after the fact

A6 SSA summarizes the reserve numbers based on overview of all the units and informs RDCs of the numbers, which for the basis for developing of daily MOR Currently, the pattern of reserve distribution across regions is not optimal

A7 MOR or Equipment Selection is based on meeting Maximum Day-Ahead Demand for the Peak Hour, accounting for interconnected flows This procedure is preceded by determination of hourly energy and demand balance including basic loads of NPP, HPP, CHP, and loads of smaller generators

A8 Previously a separate optimization subroutine was used for scheduling of HPPs It is not clear whether the procedure is still retained by NDC

A9 Hence, Equipment Selection first considers the Maximum Demand at the Peak Hour of the next day The value of demand and the peak hour change from day to day The procedure accounts for peak shavings by available HPPs, in effect, leveling the peaks across the day

A10 The MOR is based on ranking of blocks by their "Standard Cost" basis, which is the sum of each block's hourly BNL and the weighted average operating costs, i e , the area under the block's incremental cost curve divided by the operating load range The cost curves are the linear piece-wise curves constructed from block price bids The y-axis of the cost curve is the total hourly cost, and the x-axis is the block load Therefore, a point of the curve with coordinates of (100, 100,000) indicates that to run the block at 100 MW for an hour will cost 100,000 Hryvnas not including the BNL costs The Standard Cost does not include BSU

A11 MOR is done for all the thermal blocks in Ukraine, ranking all blocks in ascending order of their Standard Cost Then beyond meeting the Maximum Day-Ahead Demand, more expensive blocks are included for Cold Reserve

A12 Block Start-Up Indicators (BSI) are determined during MOR

A13 It was reported that the reason these procedures are not mentioned in the Energomarket Rules is because they are standard tasks described in literature, but was adapted to the Energomarket operations The adaptations refer to use of cost curves based on block price bids instead of the historical block "incremental cost curve", which is the total hourly cost above the BNL cost required to run the block at a given load

A14 Since MOR identifies the blocks to be used at the peak hour of the next day, additional procedures are used to adjust the selection for other hours of the day (determining hourly changes in MOR) by taking into account the BSU and operational limits Hence, the MOR for the peak

hour is based on Standard Costs, but for other hours the start-up costs and operational limits are taken into account The procedures are based on automated heuristics rather than mathematical optimization

A15 The initial MOR methodology is taken as the starting point Then going forward or backward in time, considering the demand in other hours and load-shedding at night, the ranking may deviate from the initial ranking (reverse MOR) based on consideration of cost savings and ranking of blocks by their shut-down order Most expensive blocks are shutdown first To make selections of which blocks should be kept on and which ones should be shut-down and started up again, block costs when operating at minimum load at night are compared with their start-up and shut-down costs Other factors such as Minimum On Time (MOT) and Minimum Off Time (MOF) are also taken into account

A16 In the MOR program, if some blocks are identified with the Flexibility Indicator marked as 1, and there are some excess capacity for a particular hour, then the program only loads the flexible unit at its minimum operating point However, not enough flexible equipment is available Both TPP and NPP in Ukraine were constructed as base-load units and were designed as inflexible The gas-oil fired single units are more or less flexible, but other 220-240 MW units are less so The combined gas-steam turbine plants are not considered flexible for the whole range between their Min and Max load

A17 MOR procedure does not account for transmission constraints However, transmission constraints are taken into consideration in the V2 program It is reported that other technical constraints can be incorporated into the program if it is considered necessary Currently, MOR is considered an economic ranking, and technical constraints are used later by NDC and others to adjust the ranking

A18 MOR itself does not determine the SMP Values of hourly SMP is calculated after the V2 program is run MOR only identifies the blocks to be in operation at each hour

A19 According to Mott MacDonalds, there is no explicit accounting of operating reserves in the MOR procedures "any reserves are accidental" There is also no rigorous methodology, such as load forecasting, used for prediction of day-ahead demand Current computer programs include different load shape information and use the daily information and historical data to do daily adjustments to the expected load shapes In the past (two years earlier), SSA took into account load shedding before demand prediction They were told to stop doing so by C&L, but it is not clear if the methodology was changed

APPENDIX B
REVIEW OF ENERGOMARKET GENERATION SCHEDULING

B1 This appendix presents an overview of the Generation Scheduling Program (V2) procedures used by the Settlement System Administration (SSA) in Ukraine The materials of this section are to be checked by NDC and SSA experts for accuracy

B2 The understanding of the present practice presented here includes the results of meetings held with Mr Alexander Yalovoy, Leading Engineer of SSA (April 24, and June 10, 1998)

B3 Scheduled Generation (SG) is the output of the V2 program which is an optimization algorithm, and is run after MOR selects the blocks to be operating at each hour Values of hourly SMP are determined after the V2 program is run MOR only identifies the blocks to be in operation at each hour V2 program takes the set of selected blocks as given, and finds the optimal load level for each block It is reported that documentation and flow charts for V2 may exist at NDC, and the engineer in charge is Mr Vyavoda

B4 Output of the V2 program (which is run after MOR) to determine Scheduled Generation (SG) identifies 3 points for each block in MOR Minimum Operation Load, Maximum Operating Load, or and Interim Operating Load If a block is at MOL or IOL, then its Spinning Reserve will be non-zero

B5 V2 program provides a mechanism for distribution of load across blocks based on their operating costs subject to constraints It is some sore of a sub-program for MOR The main task is optimal MOR The secondary task is to distribute the load among the selected blocks In other words, V2 program cannot rank units, instead, it optimizes after the ranks are given

B6 Loads of NPPs, HPPs, and CHPs are determines separately The V2 program takes output of NPPs and HPPs as input and basically deals only with the TPPs

B7 Energy levels of HPPs are determined by a "water pouring" program outside of V2 However, the V2 program does an optimization of HPP output by distributing the HPP loads into base load and peak shaving

B8 V2 program takes into account the internal HV connections and external inter-ties The program finds optimal SG taking into account the transmission constraints

B9 Electricity Services of NDC does an energy balance calculation once a month for the average regime which takes into account plant maintenance and calculates average balances and power flows between regions

B10 There is a library or matrix of line loss coefficients, which is accessed by the V2 program to evaluate line losses In other words, incremental line losses are pre-calculated for different levels of power flow and kept in a file The V2 program, when needed, uses an interpolation of the data available to adjust for line losses

B11 The V2 program uses the piece-wise linear incremental cost curves of TPP blocks constructed from the 4 incremental costs for the 4 elbow points or price bids of blocks Prices do not include BSU or BNL costs The output is the SG for TPPs, i e , loading points for each TPP block for each hour of the next day

B12 V2 program has no notion of flexibility The only types of generation constraints considered are Minimum Load and Maximum Load The flexibility information is used afterwards to determine the SMP based on the price of the marginal block Flexibility simply gives the dispatcher the power to stop a block based on a priority list A program of "content selection" determines which block should be stopped, and the main criterion is flexibility information

B13 When at least one two-boiler block is declared flexible, prices are non-zero

B14 There is a real life dispatch log, but it is limited due to problems of operational exchange of information between power plants and RDCs and NDC

B15 There are no limits how many times a Genco would do redecoration of availability However, they are allowed up to a certain time before actual dispatch time There are a number of technical reasons for re-declaration of availability In addition to these technical reasons, re-declarations are made for the following reasons

(i) Plant operators want to avoid penalties if a block does not follow the dispatch order

(ii) Plant operator or the Genco is playing the market, i e , gaming

(iii) Gencos see higher demand and do re-declarations for getting better money, so if they fulfill the dispatch order, payments would be done for higher availability

There may be false declarations of availability, and if the dispatcher asks for extra MW and the order is not fulfilled, the Gencos would be fined

B16 Constrained On and Constrained Off payments are not currently being made since the dispatch log is not used for calculations In additions block penalties as defined in the Energomarket Rules are also not being calculated

B17 The only reason why BNL and BSU costs are applied only during QSP, is because there was a desire to make the difference between peak and off-peak hour prices greater

B18 Determination of Instructed Generation (IG) is a task for the dispatcher based on the real-time conditions of the system

B19 Main reasons for Energomarket Rules not being fully implemented or followed include

(i) Low retail rates,

(ii) Low cash collections,

(iii) Fuel shortage and quality problems,

(iv) Top management precludes competition,

(v) Political interference and other considerations (mostly imposed by Minenergo)

B20 Constraints on development of Dispatch Log are technical (need for powerful servers) and some organizational, and have to do with communication and exchange of information at every level

B21 Bids are offered for all working blocks There are no blank price offers Some do not offer bids correctly There is no case where availability is declared but no prices are offered

B22 Maintenance scheduling is discussed between RDC and Gencos Gencos must operate available capacity which is "determined" by RDC

B23 On a daily basis there are regions in Ukraine that become isolated islands due to line bottlenecks They should be able to predict the transmission bottlenecks on a day-ahead basis Usually losses are predicted on a 2-week basis, but not daily

B24 Expected volumes of Automatic Load Shedding or Command Load Curtailment are subtracted from Load Forecast when doing AP For example, if total load forecast is 1000 MW and Automatic Load Shedding is 100 MW, then the adjusted load forecast used for AP calculations is 900 MW

B25 It reported that no provisions are made for Ancillary Service payments

B26 CHPs do not take part in competition They get paid for electricity they generate through bilateral contracts at NERC tariffs

APPENDIX C
REVIEW OF FINDINGS FROM INTERVIEWS WITH ZAKHIDENERGO

C1 Price offers are "estimates of costs" based on "standard or normative equipment characteristics", which are revised once every 5 years or after any major upgrade When a major variable such as temperature or fuel structure is changed, the cost estimates are revised Adjustments are made on actual fuel calories, humidity, ash content, temperature of cold air and other relevant variables However, cost estimation is more of an art than science

C2 Zakhidenergo experts believe that the flexibility rules are too inflexible They would like the daytime rules (such as the 15% flexibility range applied to coal-fired plants) also to apply at nighttime Blocks are declared inflexible at nighttime out of fear of unilateral and arbitrary decision by NDC to shutdown units at nighttime Inflexibility declaration prevents NDC from "playing" with those inflexible blocks

C3 It was also reported that since at present time almost 60% of the send out is from NPPs Zakhidenergo avoids declaring its thermal blocks as flexible because in such situations this would be "dangerous" in addition to being "unprofitable" In other words, inflexibility declarations are reportedly based on technical constraints, but financial issues are also a factor in consideration

C4 The poor quality coal necessitates additional usage of gas/mazout which are very expensive, especially during start-ups However, it is not clear whether these additional costs are factored in Zakhidenergo price bids [Additional inquiries will be made]

C5 No trade-off analysis or comparative calculation is made to see whether it is more beneficial to declare some units flexible and set SMP at night, instead of declaring blocks inflexible and getting zero prices but saving on some additional fuels

C6 NDC regularly informs Zakhidenergo that some of its blocks will not be used due to transmission constraints in the Donbass region However, based on the rules they should be paid the Constrained-Off Payments, but no payments are made

C7 Zakhidenergo provides a number of "ancillary services" such as reactive power control spinning reserve, cold reserve, and a number of other services However, these ancillary services are not compensated Reportedly, Minenergo requested Kiev Polytechnic to develop a recommendation for classification and pricing of Ancillary Services, but nothing has been done in terms of implementation

C8 There is no clear procedure by NDC (as seen by Zakhidenergo) for specification of reserve requirements or daily provision of reserves Again, it is reported that theory and application of reserve in Ukraine is more of an art than science If an NPP block is taken out of line for unforeseen reasons, NDC instructs Zakhidenergo to bring on line a block in 2-3 hours' time However no additional compensations are made for this service This is another area where Zakhidenergo believes existence of a Dispatch Log will result in proper compensation

C9 Zakhidenergo blocks are among the most efficient and do not usually set the SMP There are actually two sets of equipment The first set is based on conventional turbine and boiler combination The second set is based on "connected boilers" and "non-block connections" [Additional clarification is necessary] These constitute old equipment using low calorie coal, and needing additional usage of gas/mazout These blocks can set SMP if declared flexible But the price set will be above the NERC set price caps So instead they are declared inflexible A third set of more modern coal-based blocks has been decided upon but is not in production due to financial constraints

C10 Information received on a daily basis from NDC (through RDC) includes

(i) Merit Order Rankings of all scheduled blocks,

(ii) Cold Reserve for Day-Ahead (only the title but no data),

(iii) Generation Schedule for all system NPP and TPP blocks, but no data on HPP blocks,

(iv) SMP and AP for each hour, and

(v) Weighted Average Prices, SMP and AP, in Cents and Hryvnas

APPENDIX D

DERIVATION OF CON AND COF PAYMENTS OF SECTION 8.3 OF SCHEDULE 2

COF Payments

-- If $AAG_{ip} = 0$

$$Expected\ Revenue = (SG_{ip} \times BSO_i) \times SMP_p$$

$$Expected\ Cost = (SG_{ip} \times BSO_i) \times SBP_{ip}$$

$$Expected\ Lost\ Profit = Expected\ Revenue - Expected\ Cost$$

$$CP_{ip} = (SG_{ip} \times BSO_i) \times (SMP_p - SBP_{ip})$$

-- If $AAGip \neq 0$

$$Expected\ Revenue = (SG_{ip} \times BSO_i) \times SMP_p$$

$$Expected\ Cost = (SG_{ip} \times BSO_i) \times SBP_{ip}$$

$$Expected\ Profit = (SG_{ip} \times BSO_i) \times (SMP_p - SBP_{ip})$$

$$Actual\ Revenue = AAG_{ip} \times SMP_p$$

$$Actual\ Cost = AAG_{ip} \times SCIN_{ip} + (SG_{ip} \times BSO_i) \times BHC_{ip}$$

$$Actual\ Profit = AAG_{ip} \times (SMP_p - SCIN_{ip}) - (SG_{ip} \times BSO_i) \times BHC_{ip}$$

$$Lost\ Profit = Expected\ Profit - Actual\ Profit$$

$$[Note\ \ BHC_{ip}\ is\ computed\ based\ on\ (SG_{ip} \times BSO_i)]$$

$$CP_{ip} = (SG_{ip} \times BSO_i) \times (SMP_p - SBP_{ip} + BHC_{ip}) - AAG_{ip} \times (SMP_p - SCIN_{ip})$$

$$CP_{ip} = ((SG_{ip} \times BSO_i) - AAG_{ip}) \times (SMP_p - SCIN_{ip})$$

CON Payments

-- If $SG_{ip} = 0,\ AAG_{ip} \neq 0,\ SBP_{ip} > SMP_p$

$$Expected\ Revenue = 0$$

$$Expected\ Cost = 0$$

$$Expected\ Profit = 0$$

$$Actual\ Cost = AAG_{ip} \times CBP_{ip}$$

$$Actual\ Payment = AAG_{ip} \times SMP_p$$

$$If\ CBP_{ip} > SMP_p$$

$$Lost\ Revenue = Actual\ Cost - Actual\ Payment$$

$$CP_{ip} = AAG_{ip} \times (CBP_{ip} - SMP_p)$$

-- If $SG_{ip} \neq 0,\ AAG_{ip} \neq 0,\ AAG_{ip} > SG_{ip} \times BSO_i$
(This means that the marginal plant is forced to operate at a more expensive loading point)

$$Expected\ Revenue = (SG_{ip} \times BSO_i) \times SMP_p$$

$$Expected\ Cost = (SG_{ip} \times BSO_i) \times SBP_{ip}$$

$$Expected\ Profit = (SG_{ip} \times BSO_i) \times (SMP_p - CBP_{ip}) = 0$$

$$Actual\ Cost = AAG_{ip} \times SINC_{ip(new)} + (SG_{ip} \times BSO_i) \times BHC_{ip}$$

$$Actual\ Payment = AAG_{ip} \times SMP_p$$

$$Negative\ Profit = AAG_{ip} \times (SINC_{ip(new)} - SMP_p) + (SG_{ip} \times BSO_i) \times BHC_{ip}$$

Or

$$Negative\ Profit = AAG_{ip} \times (SINC_{ip(new)} - SMP_p) + (SG_{ip} \times BSO_i) \times (SMP_p - SINC_{ip(old)})$$

$$CP_{ip} = AAG_{ip} \times SINC_{ip(new)} - (SG_{ip} \times BSO_i)\ SINC_{ip(old)} - SMP_p\ (AAG_{ip} - (SG_{ip} \times BSO_i))$$

REFERENCES
LIST OF ENGLISH DOCUMENTS USED

TITLE, SOURCE, DATE, [HBIX DATED COMPUTER FILE]

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3 UK Pool Rules, Schedule 9

4 "Competitive and Non-Competitive Behavior by Generation Companies in the Energomarket Pool", Jim Stanfield, prepared for USAID, by Hagler Bailly Consulting, Inc , 23 July 1997

5 Other Working Documents developed at Hagler Bailly Kiev

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