Seeking for the Optimal Market

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Abstract: The power market is a complex phenomenon with physical, economical and regulation aspects.
In this paper we show a methodology how a decision can be assessed, how can we measure if we getting closer or not to the optimal market conditions.
The market is measured by heuristical Key Performance Indicators based on qualitative functions. The global outcome can be tuned by different optisation techniques.

Keywords: power market, heuristic qualitative assessment, optimisation

1 Introduction

From the beginning of the 90's most of the national power system structures has been changed by the deregulation process. The liberalized market has no uniqe model but has many "puzzle" elements. The picture of the power market in the world is a little bit fuzzy but some trends can be identified. Nobody talks about finished deregulation, this is only a process in progress. Grabner discusses in detail the performance of the Hungarian deregulated system. [7]

But where we are now? Can the market be better? Making, designing the market we face with the problems:

- Asses discrete situations (see Fig. 1)
- Smooth tuning of some variables, looking for the best (better) solution

Only for ideal questions can be ideal answer found. We have always an existing, non optimal situation that comes from the history. We must make it better, but we can not make a "tabula rasa" situation, the real complexity must be handled.

In the electricity trade and market we support decisions for the better market and encourage the mind opening. We seek the answer for the questions: How the regulation helps the mutual benefits? Where to invest and develop?

The electricity business has a lot of stakeholders:

- Society/small customers
- Large customers
- Energy suppliers (Genco, Transco, Disco)
- The greens
- The policymakers
- Device producers
- System vendors
- Miners, water lobby, etc.

The stakeholders have a lot of parallel existing aspects, different priorities.

The market (the regulation) is optimal, if all the participants (stakeholders) are satisfied and the total outcome is acceptable for most of them.

2 Mapping the Problem

At the first step the different aspects must be normalized that means we handle problems only with the same dimension, with relative similar weights and values.

If there are any too large forces in our decision space - no free decision can be made. The too small effects are not interesting, no worth to deal with the tiny details.

Instead of the continuously changing world we handle some discrete snapshots, some states.

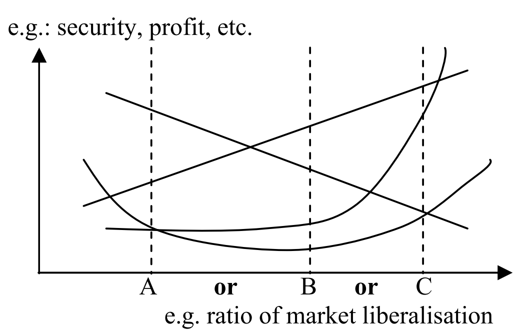


Figure 1

Discrete choice possibilities (A or B or C)

3 Methodology

Kromer recommends forward and backward decision making strategies to tackle problems related energy strategy [7]. In our approach we handle similar problem, but we are going to measure the quality, the possible effects of a decision. We handle not only the direction but the "value" of the decision too.

For finding better market conditions we apply the following steps:

A Problem identification

B Question formulation

C Definition of Key Performance Indicators (KPIs)

D Identification of the influence factors on the KPIs

E Setting up qualitative KPI functions

F Formalization of compound function, general outcome

G Maximisation of the outcome

3.1 Problems

The following list gives a special set about the present problems of power systems under deregulation changes (e.g. in Hungary):

- There is no real market yet
- Lack of investment into power plants, new lines
- There is no investment in renewable generation for the lack of subsidy
- Misuse of the cheap balancing energy
- High ratio of flat schedule import energy
- Moving from ISO to TSO
- Exists too large market power (Herfindahl index Σp^2) [1]
- There is no liquidity [1]
- High stranded costs [1]
- There are too many small gas motor units in the network
- The biomass means old type coal fired power plants changed to wood firing
- The Obligatory Power Purchase (OPP) of the government for renewable energy makes the schedule planning difficult
- Trade and transit instead of local generation
- Mutual help works no more in a trade environment
- Trading blocks are not flexible
- Business constraints instead of technical evidence
- For profit raising the maintenance level and the security decreased too, etc.

Abused market behaviour

- Shifted maintenance
- Fixed balancing energy price
- Flat import
- Gas motor and OPP
- Scheduled outage
- Enron type games [2]

3.2 Questions

From the szerteágazó problems some clear questions can be distillized that requires decisions:

- Monopolistic/re-regulated **or** deregulated structures (level of unbundling, no. of players)
- Fossil **or** Nuclear plants
- To develop **or** not the network (build **or** not a new line)
- Maintain **or** not
- Profit **or** supply priority
- Traditional, concentrated **or** distributed generation (DG)
- Traditional **or** renewable sources (REN)
- Demand growth **or** efficiency growth
- AI **or** simple tools, over-controlled technology
- Market model (single buyer/pool/bilateral/etc.)
- Type of the PX, bidding mechanism
- Place of the PX
- Auction type, etc.

3.3 Key Performance Indicators (KPIs)

The efficiency of the market, the performance of the power system is measured by Key Performance Indicators. The KPIs can be defined heuristically based on practice and customs. Here is given an eventual KPI set organized into the "STEPLE" structure:

↓

Social aspect

- Employment
- Right to energy (access)

- Social mission
- Value of human positions (bureaucracy)

Technological aspect

- Security of supply
- Quality of energy
- Efficiency of production and usage
- Standardisation
- Integration

Economic aspect

- Costs
- End price of the energy
- Growth rate of the economy
- Profitability, ROI
- Accumulation of the investment/development
- Lifetime of the assets

Political aspect

- Role of the state decision/subventions
- Priority of energy supply
- Group interests/lobbying
- National interests

Legislation aspect

- Number of the rules
- Strictness of penalties
- Controlled competition
- Entry barriers
- Corruption factor
- Cooperative work between the players

Environmental aspect

- Greenhouse effect
- Used/wasted materials
- Area destruction
- Ecological destruction
- Energy resources

3.4 Influence Factors

With the KPIs the market can be assessed, measured. These results can be influenced by direct and indirect factors. These parameters are in the hand of the market regulator:

Direct Control possibilities over the market

- Physical limits
- Set up new devices, network, plants
- Constraint schedules

Indirect Control possibilities over the market

- Obligatory prices
- Price cap change
- Structural changes

Administrative Control possibilities (limits)

- Taxes
- Obligatory Power Purchase (OPP)
- Legislation
- New market forums / day-ahead, intraday PX, etc.

Parameters to set:

- Price cap
- Price of the balancing energy
- OPP price
- Tarifs (net/ISO/PX)
- Level of the import
- Level of the investment and development
- Level of the control
- Level of the aggregation and outages (Europe/Asia/Africa) - microgrids
- Trading strategies
- Triumvirate of regulation/physical/trade
- Measure of the market/regionality

Based on these influence factors can be defined independent variables for the individual KPI functions.

3.5 KPI Functions

The relation between the influence factors and the KPIs are defined in KPI functions. Theoretically possible to define analytical relation between the variables and KPIs but at first sight we handle the qualitative trends. E.g.:

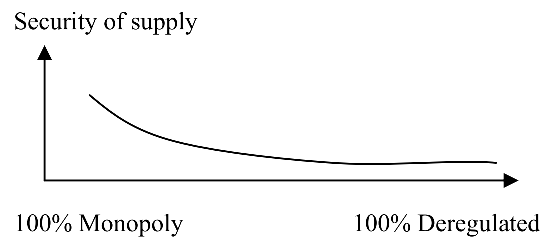


Figure 2

A KPI function of energy supply security in the deregulated environment

It means:

As result of the deregulation, the security of the supply decreases (lack of maintenance, control, investment, etc.).

FigureFigure 4

Some KPI functionshows a set of KPI functions:

We applied the following qualitative categories:

Type — *Qualitative function*

A = valley

B = sudden downhill

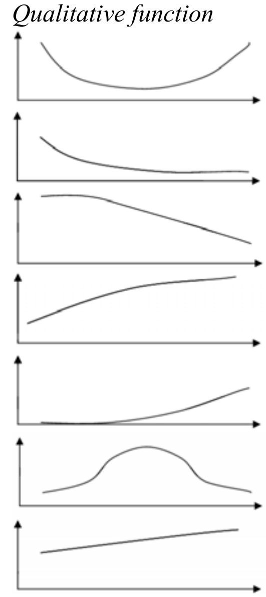
C = late downhill

D = early uphill

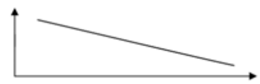
E = late uphill

F = hat

G = straight uphill



H = straight downhill



I = into the ground

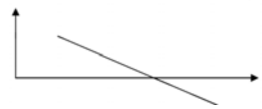


Figure 3
Typical KPI function shapes

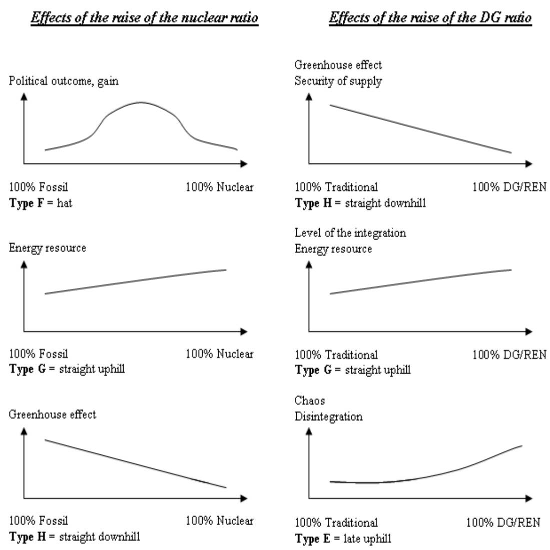


Figure 4
Some KPI function

3.6 Compound Function, General Outcome

The KPIs can be included in a KPI function matrix, that shows the relation between the influence factors (independent variables) and KPIs. The letters in the matrix shows the type of the qualitative function. In practice a market can be described by cca. 15 influence factors (see point D – these are the rows of the matrix) and cca. by 40 KPI factors (see point C – these are the columns of the matrix).

KPI function matrix	independent ← variables	Energy security	Quality	……….
weight factors→		w_1	w_2	w_i
Monopolistic/re-regulated or deregulated structures (level of unbundling)	x_1	**B**	**A**	.
Traditional or renewable sources (Trad → REN)	x_2	**H**	**H**	.
To develop or not the network (build or not a line)	x_3	**E**	**H**	.
Maintain or not (N→Y)	x_4	**G**	**G**	.
……….	x_n	.	.	.

Figure 5
The KPI function matrix

The different lobbies (financing, industry, social, environmental, etc.) represent different importance in specific questions, e.g. in case of "Construction of a new water dam". Their priority is mapped to the weight factors.

The market is measured by the set of the KPIs. The whole outcome is a linear combination of KPI functions:

$$\text{Outcome} = w_1 * f_A(x_1) + w_2 * f_B(x_1) + \ldots + w_{i-1} * f_P(x_n) + w_i * f_Q(x_n)$$

where

$f_{A\text{-}Q}$ = qualitative functions

$x_{1\ldots n}$ = influence variables

$w_{1\ldots i}$ = weight factors

3.7 Decision Problems

3.7.1 Is it better?

In the market planning we face the question: *"Is the proposed option better or not?"*. In this case the weighted outcome of the market measure can be forward calculated, ad the option can be easily assessed with a simple comparison:

If

Outcome (Option_A) > Outcome (Option_B)

Then

Option A is recommended

A typical optional question is e.g.:

Do we set up a 2x1000 MW nuclear power station or not?

3.7.2 Maximalisation of the Outcome

In optimisation question we are looking for the optimal set of the influence variables. In this case we are looking for the maximum outcome of all functions included into the matrix.

As demonstration purpose we see the dotted part of the matrix (see Figure 5
The KPI function matrix). The variables are independent, the maximum can be seek independently for variables x_1 and x_2.

For this simple demonstration case x_1=0 and x_2= 100 (%) brings the maximum for this part of the matrix. It means that the energy security and quality is the best in the non deregulated situation, using the traditional generation technique (see Figure 6
Uncoupled variables). Certainly, this was only two aspects of the dozens, so the real results would be more subtle.

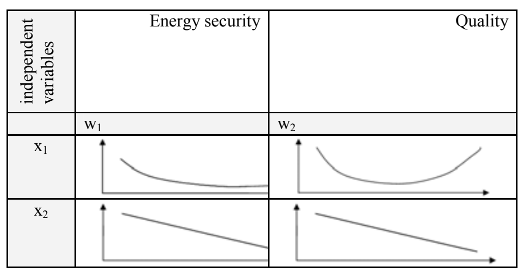


Figure 6

Uncoupled variables

In some case constraints define relations between the independent variables, e.g. the financial amount of the network maintenance and development is limited:

$x_3 + x_4. =< \text{Value}_{fixed}$

$x_4. =< \text{Value}_{fixed} - x_3$

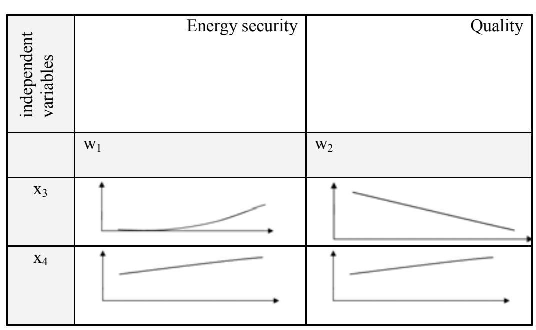


Figure 7

Coupled variables

If all the money is spent

$x_4. = \text{Value} - x_3$

substituting it into the previous matrix part:

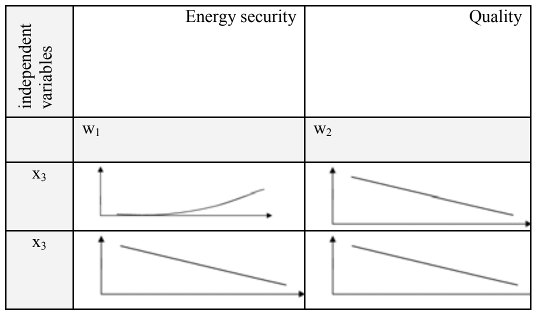


Figure 8

Substituted variables ($x_4 \rightarrow x_3$)

After weighting the maximum of the sum function can be find too, e.g.:

Value = 100 penny

$x_{3development}$ = 0 penny

$x_{4maintenance}$. = Value - x_3 = 100 penny

In the reality the rows of the matrix is coupled by many constraints (mostly by time and money). In this case the optimal values of the free variables can be find by linear programming methods.

Although the above mentioned processes has different time scales (short-time power security, long-time environmental effects), in the decision making discrete time steps can be investigated: e.g. 1 year.

Conclusion

Recently we investigate the different effect of three real options:

- Nuclear plant life extension
- Water dam/storage pump construction
- Windmill park set up

From one hand the method contains some uncertainties through the qualitative KPI functions and the individual weight factors. From the other hand the method is quite certain tool for qualitative sensitivity analysis.

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Biographies

Peter KADAR**, was born in 1963 in Budapest. He received his M.Sc. in 1987; PhD. in 1994 at the Technical University of Budapest. His preferred topics are the expert system applications to the power systems.**

He worked for the Power Station and Network Engineering Company (EROTERV) till 1991 and for the KFKI - MSZKI IAFO, Budapest (Research Inst. for Measurement and Computing Techniques, Department of Industrial Application) till 1996. In the next five years period he was the managing director of DYNAdata Ltd. (medium size software development company). In the industry he dealt with the power system control including different applications of intelligent functions and neural networks, like load-forecasting, simulators, alarm filters, etc.

At present he is an associate professor at the Budapest Tech, Department of Power Systems. He is member of the Hungarian Electrotechnical Association and he is the editor in chief of the transactions of this association. He is member of John von Neumann Computer Science Association, of IEEE Hungarian PE chapter.

APPENDIX: **KPI function matrix**	← *Independent variables*	**Social**	Employment	Right to the energy	Value of human positions	Social mission	**Technology**	Energy security	Quality	Efficiency	Standardisation	Integrity	**Economy**	Costs	Price of the energy	Growth rate	Profitability, ROI	Investment/development	Life time of the assets	**Political**	State decision	Priority of en. supply	Group interests/lobbying	National interests	**Legislation**	Number of rules	Penalties	Control	Competition	Entry barriers	Corruption	Cooperative work between the players	**Environmental**	Greenhouse effect	Ecological destruction	Energy resources	Used/wasted materials	Area destruction
weight factors →		W_s	w_1	w_2	w_3	w_4	…																															
Monopolistic or deregulated structures (level of unbundling)	x_1		**B**	**B**	**C**	**C**		**B**	**A**	**G**	**B**	**B**		**B**	**B**	**-**	**A**	**C**	**B**		**C**	**B**	**A**	**D**		**G**	**G**	**B**	**D**	**B**	**D**	**E**		**-**	**-**	**-**	**-**	**-**
From fossil toward the nuclear plants	x_2		**C**	**E**	**B**	**-**		**G**	**E**	**E**	**G**	**G**		**B**	**B**	**E**	**D**	**E**	**D**		**E**	**E**	**E**	**E**		**B**	**B**	**E**	**C**	**E**	**-**	**B**		**H**	**B**	**E**	**B**	**B**
Level of network development	x_3		**E**	**E**	**E**	**-**		**E**	**H**	**E**	**E**	**E**		**E**	**E**	**-**	**C**	**E**	**E**		**-**	**E**	**E**	**E**		**-**	**-**	**-**	**G**	**C**	**-**	**G**		**-**	**E**	**E**	**E**	**E**
Level of maintenance	x_4		**E**	**E**	**E**	**-**		**G**	**G**	**G**	**G**	**G**		**G**	**G**	**-**	**H**	**G**	**G**		**-**	**G**	**F**	**G**		**-**	**-**	**-**	**G**	**C**	**G**	**G**		**-**	**-**	**G**	**G**	**-**
From traditional towards the distributed gener.	x_5		**G**	**G**	**G**	**G**		**G**	**G**	**H**	**G**	**G**		**G**	**G**	**G**	**H**	**G**	**H**		**-**	**G**	**G**	**G**		**G**	**-**	**-**	**G**	**H**	**G**	**G**		**H**	**H**	**G**	**G**	**G**
From traditional to renewable sources	x_6		**G**	**G**	**G**	**G**		**H**	**H**	**G**	**G**	**G**		**G**	**G**	**G**	**H**	**G**	**-**		**G**	**G**	**G**	**G**		**G**	**-**	**-**	**G**	**H**	**G**	**G**		**H**	**H**	**G**	**G**	**H**
OPP price	x_7		**H**	**H**	**-**	**G**		**-**	**-**	**-**	**-**	**-**		**-**	**G**	**H**	**G**	**G**	**-**		**G**	**G**	**G**	**G**		**-**	**G**	**G**	**G**	**G**	**G**	**H**		**H**	**H**	**G**	**-**	**H**
Tariffs (net/ISO/PX)	x_8		**G**	**H**	**G**	**G**		**G**	**G**	**-**	**G**	**G**		**G**	**G**	**-**	**G**	**G**	**G**		**-**	**G**	**G**	**-**		**-**	**G**	**G**	**H**	**G**	**G**	**H**		**-**	**-**	**-**	**G**	**G**
Level of the general investment	x_9		**G**	**G**	**G**	**G**		**G**	**G**	**G**	**G**	**G**		**G**	**H**	**G**	**G**	**G**	**G**		**G**	**G**	**G**	**G**		**G**	**G**	**H**	**G**	**G**	**G**	**G**		**H**	**G**	**H**	**G**	**G**
Level of the import	x_{10}		**H**	**G**	**H**	**H**		**-**	**G**	**-**	**-**	**-**		**H**	**H**	**G**	**H**	**H**	**H**		**G**	**H**	**G**	**H**		**-**	**H**	**H**	**G**	**H**	**G**	**H**		**G**	**G**	**G**	**H**	**G**
Level of the control (raising)	x_{11}		**G**	**G**	**G**	**G**		**G**	**G**	**G**	**G**	**G**		**G**	**G**	**-**	**H**	**G**	**G**		**-**	**G**	**G**	**-**		**G**	**-**	**G**	**-**	**G**	**-**	**G**		**-**	**-**	**-**	**G**	**-**
Level of the aggregation, complexity	x_{13}		**G**	**G**	**G**	**G**		**G**	**H**	**H**	**G**	**G**		**H**	**H**	**G**	**G**	**G**	**G**		**G**	**G**	**G**	**G**		**G**	**-**	**G**	**G**	**H**	**G**	**G**		**H**	**G**	**G**	**G**	**G**
Measure of the market/region	x_{14}		**G**	**G**	**G**	**G**		**G**	**G**	**-**	**G**	**G**		**G**	**H**	**G**	**G**	**G**	**G**		**G**	**G**	**G**	**G**		**G**	**-**	**G**	**G**	**H**	**H**	**G**		**-**	**G**	**G**	**-**	**G**