NEW APPROACH APPLAIED TO REDUCE THE VULNERABILITY OF ENERGY SYSTEMS

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Abstract: We present the causes generating vulnerabilities sand propose the models for diminishing the risks and catastrophes based on the education of the human resources incorporated in the evolution of the local power system and not only. We specify the fuzzy structure of the model for increasing the quality of the human factor and of the models for rating the human resources in power plants and the networks of the power systems exemplified on the evolving structure of the Romanian installations subject to dynamic reconfiguring over the forecast interval (2020 ÷ 2035). Innovative expert systems are proposed to reduce beforehand the vulnerabilities of the structure of power systems with the human resources reconfigured arhemic. This approach specifies both the abilities of the workers and the performance of the managers involved in the transformation of the damages into resource saving generated by the re-engineering of the software applied within the National Power System. These actions involve the training of designers and managers based on the orientations dictated by the project management that appeals to the model of the potential creator of the human resources approached in the design of the operational researches

Key words: management, human factor, operational models

1. CAUSES GENERATING VULNERABILITIES AT THE LEVEL OF THE HUMAN RESOURCES INCORPORATED INTO THE POWER SYSTEMS AND SOLUTIONS FOR THEIR MITIGATION

The main causes generating vulnerabilities in the National Power System by means of the human resources are in short the following:

1. Inconsistent education training for the operators and managers of the National Power System structure

The treatment and reduction in the professional vulnerabilities can be achieved by parallel educations (communication, change, spare time management, avoiding conflicts and stress, learning, new knowledge management, career training, modeling of the dynamic characteristics of the management team to develop and apply quantum and super-quantum decisions, etc.).

2. Failure to apply in practice the re-engineering of the mentality as related to the results of work.

The new approach based on the elimination of intellectual pollution and decrease in errors in the activities of implementing and carrying on the design concept.

3. The lack of holistic risk approaches, basic and complex disasters, including the removal of the causes generating chaos.

The modeling of the activities that cannot be found in the real processes as shown in the operational research based on the mathematical theory of real facts. Under the new approach of the development of power systems the readers of these Communications will be informed on the structure of power objectives modelled in operational researches that emphasize the calculation mode of the main vulnerabilities (risk, catastrophe, chaos) and of the auxiliary causes that disturb the normal operation of the power systems undergoing dynamic evolution.

4. Failure to know the managerial concept of visioning (Fig. 1.1) and failure of applying the excellence factors (Fig. 1.2) complete the chain of the causes generating holistic vulnerabilities.

2. MODELS FOR THE FORMING OF THE QUALITY OF THE HUMAN FACTOR BUILT IN THE ENGINEERING OF VALUE

2.1 Structure of the general models in operational researches

$$C_{tac} = \sum_{i=1}^{dv} (1+_{ra}+r_{in}+r_{rs})^{-i} [(C_{DD}+C_{CC}+ +C_{SS}+C_{RU}+C_{EF}+C_{DC}) + c_p - R_t] \quad (3\text{-}1)$$

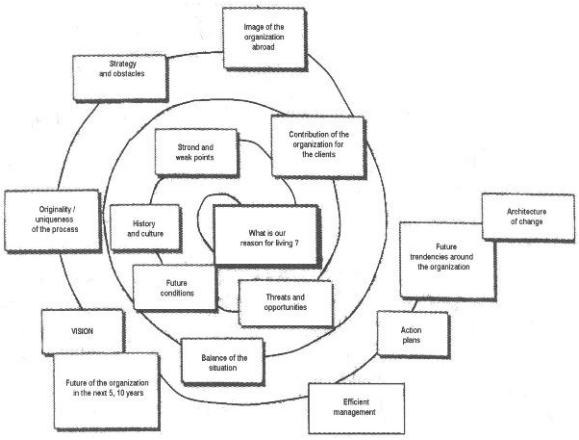

Fig. 1.1 Management of visioning

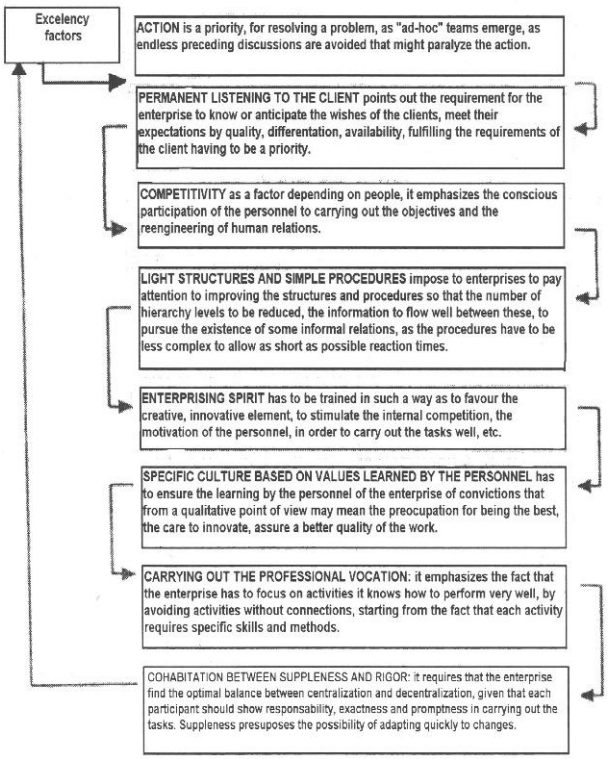

Fig. 1.2 Factors for assuring the excellence of human resources

$$C_{DD}=\left[\left(C_{\substack{\text{information}\\\text{search}}}+C_{forecast}+C_{risk}+C_{catastrophe}+C_{chaos}\right)+ +c_pR_{DD}\right]$$

$$C_{CC}=\left[\left(C_{\substack{\text{aquiring fuels}\\\text{and other}\\\text{materials}}}+C_{\substack{\text{duindling}\\\text{expectations}}}+C_{\substack{\text{power}\\\text{maket}\\\text{study}}}\right)+c_pR_{SS}\right]$$

$$C_{SS}=\left[\left(C_{\substack{\text{techno logical}\\\text{material}\\\text{reingeneering}}}+C_{\substack{\text{economic}\\\text{state}}}+C_{quality}\right)+c_pR_{SS}\right]$$

$$C_{RU}=\left[\left(C_{\substack{\text{intensive}\\\text{learning}}}+C_{\substack{\text{workplace}\\\text{ergonomy}}}+C_{\substack{\text{post}\\\text{design}}}+C_{\substack{\text{salaries}\\\text{and}\\\text{productivity}}}+ +C_{\substack{\text{informatic}\\\text{dialoguq}}}+C_{\substack{\text{labour}\\\text{reward}}}\right)+c_pR_{RU}\right] \quad (3\text{-}2)$$

$$C_{EF}=\left[\left(C_{\substack{\text{formarea}\\\text{fondurilor}}}+C_{\substack{\text{proiectarea}\\\text{preturilor}}}+C_{\substack{\text{strategia}\\\text{birotica}}}\right)+c_pR_{EF}\right]$$

$$C_{DC}=\left[\left(C_{\substack{\text{continuarea}\\\text{deciziei}}}+C_{\substack{\text{formarea}\\\text{managerilor}\\\text{antreprenori}}}+C_{\substack{\text{comunicafre}\\\text{holistică}}}\right)+c_pR_{DC}\right]$$

Where: rate for interest (d), inflation (in) and risk (rs); dv = lifetime of the designed power objective; C = costs involved in the sustainable development activity (C_{DD}), in the trade activity (C_{CC}), in the production activity (C_{SS}) activities of the human resources involved (C_{RU}), economic - financial activities (C_{EF}) and decision - communication activities (C_{DC}), Cp = penalty factor, R = restrictions upon the six operators of operational research.

The main vulnerabilities in the new structure of power systems in which the human resource involved can be calculated in the engineering of value with models of the form:

$$C_{risk}=(p_{ene}\cdot E_{nl}+i_{sp}P_{av})=(200pei\cdot tav\cdot Pav+isp\cdot \cdot Pav);\ Pav=Pstandby$$

$$C_{catastrophe}=p^{failure}_{probability}C^{power\ failure}_{consequence}(P_{cat}>P_{stan\,dby})$$

$$C_{chaos}=p^{failure}_{probability}C^{power\ failure}_{consequence}(P_{av}=P_i)$$

The vulnerabilities provoked by the non-quality of the real activities in the power system is determined as foliows:

$$C_{nonquality}=\left\{\left[C_{\substack{\text{failure owarn}\\\text{decision make sin}\\\text{realtime}}}+C_{\substack{\text{failureprepare}\\\text{trulythe human}}}+ +C_{\substack{\text{other}\\\text{costs}}}\right]+c_pR_{nc}\right\}$$

$$C_{\substack{\text{other}\\\text{costs}}}=\left\{\left[C_{\substack{\text{failureprepare}\\\text{quality studies}}}+C_{\substack{\text{failure study}\\\text{in depth}\\\text{of environmental}}}+C_{\substack{\text{cost of an}\\\text{unefficient}\\\text{inf ormatic}\\\text{system}}}+C_{\substack{\text{error costs}\\\text{penalties}}}+C_{\substack{\text{waste}\\\text{cost}}}+C_{\substack{\text{inquiry cost}\\\text{at client}}}\right]+c_pR_{nc}\right\} \quad (3.3)$$

2.2 Operațional models for increasing the quality of the human factor by intensive learning

$$C_{tan}=[C_{DD}+C_{CC}+C_{SS}+C_{RU}+C_{EF}+C_{DC}+c_pR_{tan}]= =f(X_M,H_i)$$

$$X_M^{(x)}=\begin{cases}0\ \text{if}\ x\le 1000;\\ \left[1-\dfrac{1}{(x-1000)^2}\right]\ \text{if}\ x>1000\end{cases} \quad (3.4)$$

$$H_i=H_i^{nf}+H_i^{f}=\sum_i p_i\ln p_i+\sum_i p_iS[X_M(x_i)]$$

Where: C_{tan} = annual costs allotted for training the human resources in the arhemic approach; X_M = the behavior of the human resources upon the occurrence of vulnerabilities; H_i = Information entropy of fuzzy (f) events and non-fuzzy (nf) ones; x = factors generating vulnerabilities; p_i= success probability $S[X_M(X)]$ = degree of uncertainty of the examined system.

The modeling of the behavior of the human factor submitted to training can be carried out by programmable logic controllers (A_p) destined both to training and to the trainer in the relation (3-5):

$$A_{pp}=[S_1;\ T_1;\ F_1];\qquad A_{pi}=[S_2;\ T_2;\ F_2] \quad (3\text{-}5)$$

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The training ceases if the cardinal of the states S_1 is equal to S_2.

$$\text{Card } S_1 = \text{Card } S_2 \qquad (3\text{-}6)$$

After training, the human factor is submitted to a practical test for the management of a specialist team in the field, for a year. If their knowledge based decisions lead the activity to profit, then the trainer can take over the management of a department. If the profit of the department over the duration of the experiment is a positive one, then one can hand in to the candidate towards the managerial positions up to the limit of the competencies proved at the control of the design activities, respectively the operation of the energy industrial installations. The number of specialists selected for the operation of the power installations for the production and transmission of power to power plants and network subsidiaries to consumers is determined by models of the form:

a. ***Power plants***

$$n_{pnc} = \frac{k_i}{g_{inf} \cdot \sqrt{P_i}}; \quad n_{pnp} = \frac{k_i \cdot k_p}{g_{inf} \cdot \sqrt{P_i}}; \qquad (3.7)$$

b. Power network subsidiaries

$$n_{pi} = n_0 + c_1x_1 + c_2x_2 + c_3x_3;$$

Where: n_{pnc}; n_{pnp} = current (ne) and progressive (np) rating indicators, when we use a certain type of fuel (k_i) k_p = progress indicator achieved in power plants wiîh new technologies; P_i = installed power; g_{inf} = degree of computerization, n_{pi} = number of personnel at the level of the subsidiaries of electric networks, n_o = initial staff; ($c_1 \div c_3$) = correction factor; ($x_1 \div x_3$) = influencing factor (x_1 = workers; x_2 transferred power; x_3 = the number of consumers on the energy market in thousands of participants. For the National Power System we used the values: c_1 =0.125; c_2 = 0.05; c_3 = 0.5). [1÷7]

The personnel existing in 2009 at the level of the NPS of 2.4 [man/MW] will b reduced to 1.6 [man/MW] in 2025 by applying the models (1-7).

The general architecture of an intelligent training system can be observed on Figs. 1-3 that by opening up the links between the NPS and the consumers (Figs. 1-4) allows the limitation to the effects of non-quality of the human factor (Figs. 1-5) if we observe the model of the risk spiral (Figs 1-6).

$$C_{tac} = \sum_{i=1}^{dv} (1 + r_d + r_{in} + r_{rs})^{-i}[(C_{DD} + C_{CC} + C_{SS} + C_{RU} + C_{EF} + C_{DC})_i + c_p + R_t] \qquad (3.8)$$

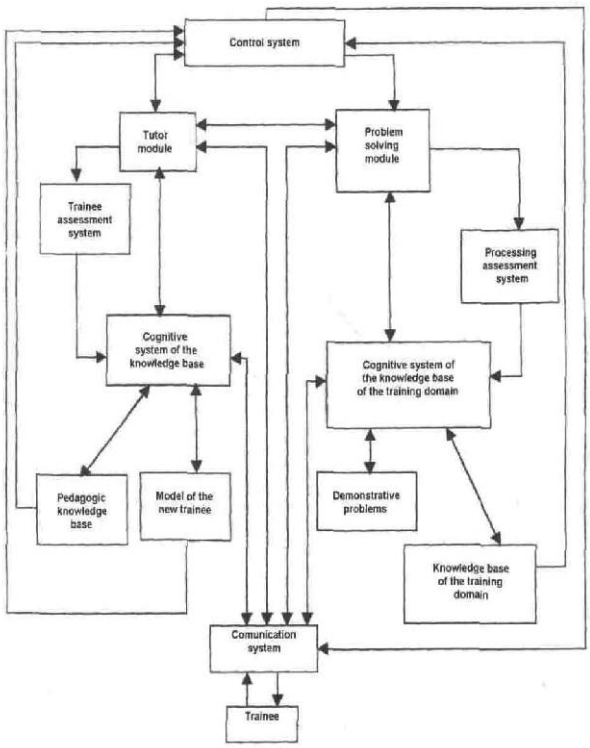

Fig. 1.3. General arhitecture of an intelligent trening system

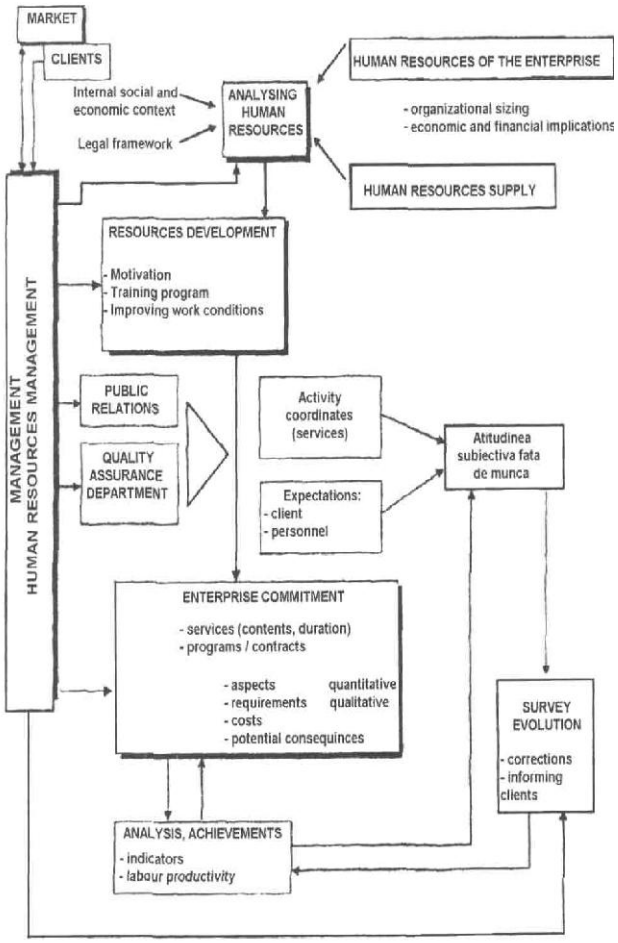

Fig. 1.4. Human resources management and opening therelations to the client

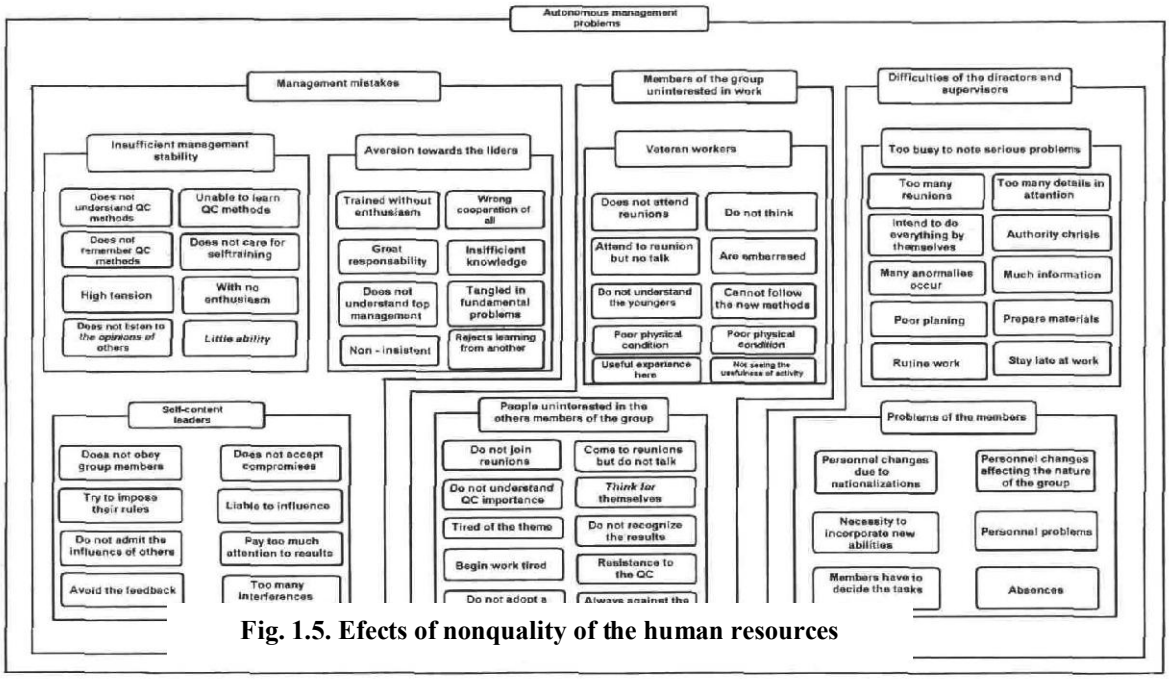

Fig. 1.5. Efects of nonquality of the human resources

Fig. 1-5 Effects of nonquality of the human resources

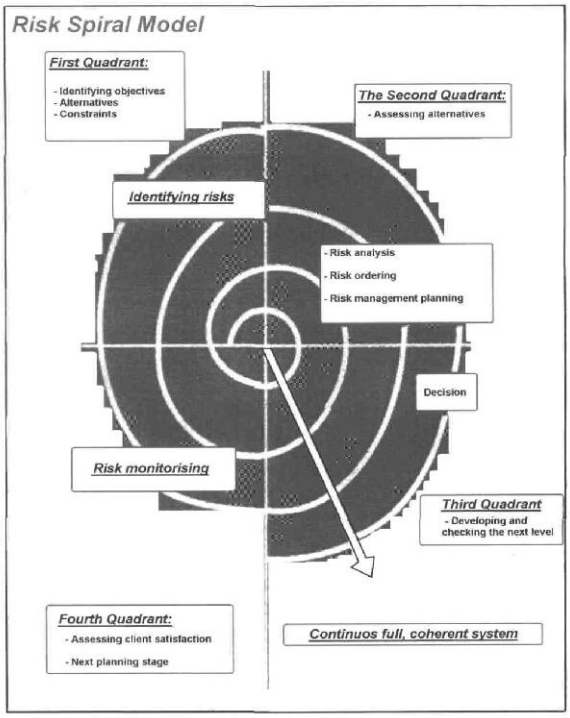

Fig. 1.6. Model of the process risk management spiral

3. ANTICIPATORY EXPERT SYSTEMS DESTINED TO THE SUPERVISION AND REDUCTION IN THE VULNERABILITIES IN POWER SYSTEMS

The approach and reduction in the vulnerabilities at the level of the power systems is performed by observing the algorithms presented in the diagrams of the figures (1-7) (1-10),

The main tasks of the expert and neuroexpert systems likely to reduce the overall vulnerabilities of the power structures with human resources incorporated refer to the following practical approaches:

- Diagnosing the installations on the basis of the anticipatory monitoring of the vulnerabilities generated by complex causes (human interventions, risk prone states, etc.)
- Programming, surveying, analyzing the decision making actions for the reduction in holistic vulnerabilities
- Computer assisted management in order to perform the arhemosistemic building of the designed productivity
- Determining in real time the supplier - consumer behavior supervised by entrepreneurial managers
- Establishing the sustainable development strategy (design and operation of the power installations) computer assisted based on the quantification of the vulnerability of the human resources involved in the unfolding of real events
- Training the human resources (designers and managers) by decisions that ensure the achievement of the of the highly efficient parameters at the level of all the real functions monitored by expert and neuroexpert systems (Fig 1.9 and Fig. 1-10).

The criteria of conceptual assessment of the expert systems and of the models that make it easier to calculate

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the saving of resources by reducing the vulnerabilities refer to the following significant orientations:

- the swiftness, especially when the expert system operates on a multiprocessor architecture
- reliability - surveys the continuous operation of the system even if a problem was not resolved optimally;
- the efficiency - refers to the resolution times that for the monoprocessor systems have suboptimal values
- the quality of the solution results from the distribution of knowledge on knowledge modules
- the clarity - results from modularity as the program is readable if it requires a smaller amount of information for decision making.
- Adequacy to the applicable domain - is relevant as the experts trust more the system architecture reflecting their own abstracting and conceptualization
- the designing costs decrease if the expert systems are designed in a modular way as the knowledge acquisition from the human experts can be performed in parallel.
- The adoption and operation of expert systems require:
- changes in all the fields of activity (design, mounting, operation).
- changes in the mentality regarding labor;
- a considerably higher quality, etc.
- the application of the following interactive strategies: functional restructuring, holistic competition and protocol strategy

The efficiency of implementing the expert and neuroexpert systems within power systems can be determined by means of the following economic and engineering models:

a) Capital formation rate;

$$r_{fc} = \frac{E^{value}_{economy} + V^{economies\ resulted\ from}_{avoiding\ vulnerability} - C^{expert\ systems}_{operation\ costs}}{I^{total}_{investments} + I^{used\ expert\ system}_{investments}}$$

$P_{av} = 0{,}25\ P_i$ = standby
P_f = operating power $(0{,}8 \div 0{,}9)\ P_i$; (4.1)
I_{sp} = specific investment

The expert system gets profitable if:

$$r_{fc} > 1\left(\frac{lei\ income}{leu\ invested}\right)$$

b) The cost of the hard-soft structures regarding the acquisition and utilization of expert and neuroexpert systems:

$$C^{hard}_{soft} = \left[C^{hard}_{instalation\ cost} + C^{replacing\ cost\ after\ expiring}_{of\ economic\ operating}\right]$$

$$c_{soft} = p^{soft}_{price} \cdot N^{number\ of\ spfts}_{annualy\ replaced} = \frac{\left(1+r_{exp}\right)\cdot \sum_i (1+r_{app})_i\, C^{cost\ of}_{program\ product}}{\sum_i (1+d_{vpp})_i\, n_{uppi}}$$

Where: r_{exp} = price soaring rate; r_{app}= return rate; d_{vpp}= the lifetime of the program product; n_{uppi} = the number of the users of the program products (I).

c) The Information entropy of the power systems equipped with expert and neuroexpert structures and the annual net income achieved.

$$E^{information}_{entropy} = -3{,}32\left[-p_s \lg p_s - p_i \lg p_i\right] = minimal$$

$$V^{net\ income}_{annualy\ recived} = \left(E^{economic}_{effect} - E^{economic}_{effort}\right) > 0$$

Where: p_s and p_i = success probability (p_s) and failure probability (p_i) of the power system in which the holistic vulnerabilities were reduced.

Due to the intellectualizing the power units in the NPS by computerization reached an increase in productivity three times higher and to economic effects exceeding the efforts.

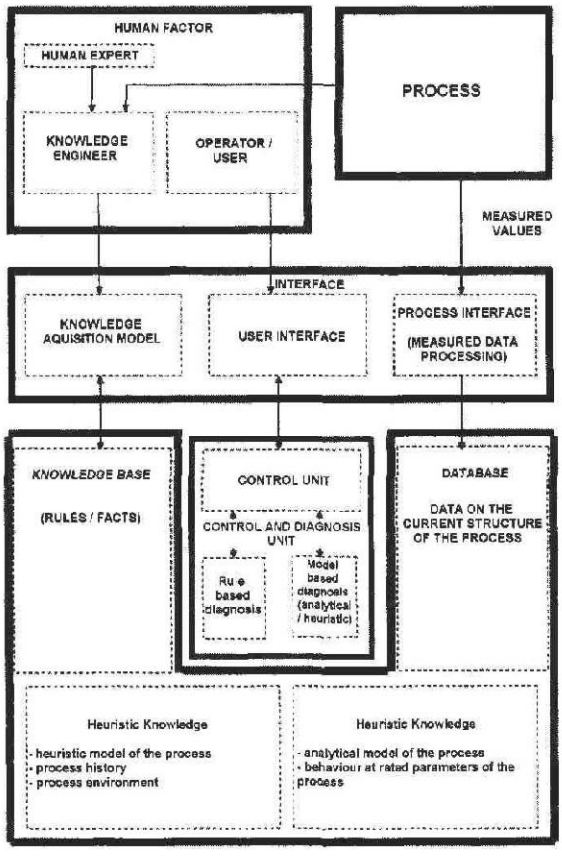

Fig. 1.7. Architecture of an anticipatory expert system destined to diagnosing power installations

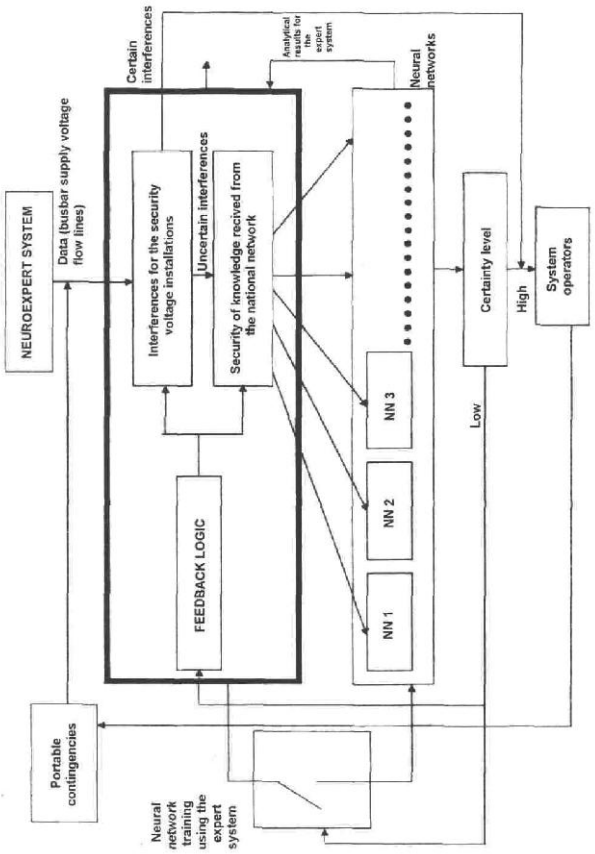

Fig. 1.8. Neuroexpert system for the control of highy efficient power objectives

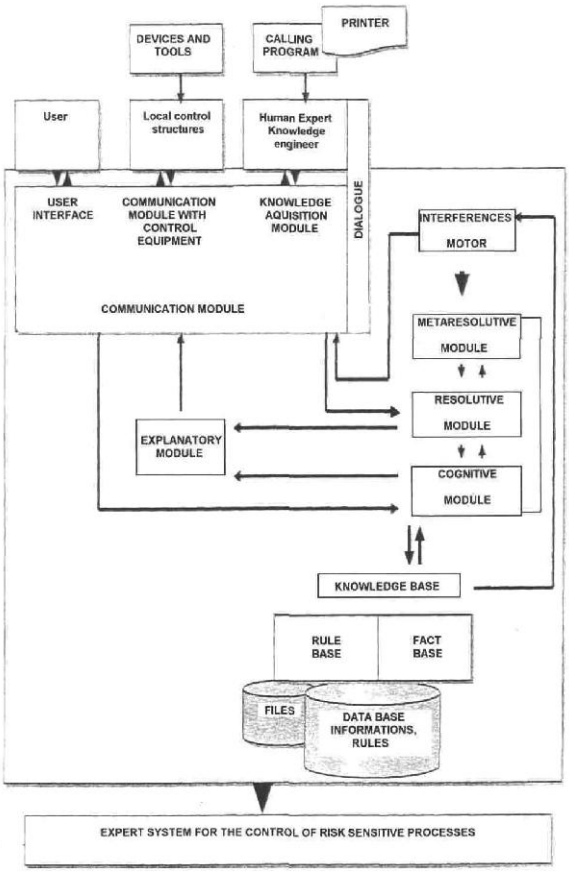

Fig. 1.9. Expert system for the control of risk sensitive process

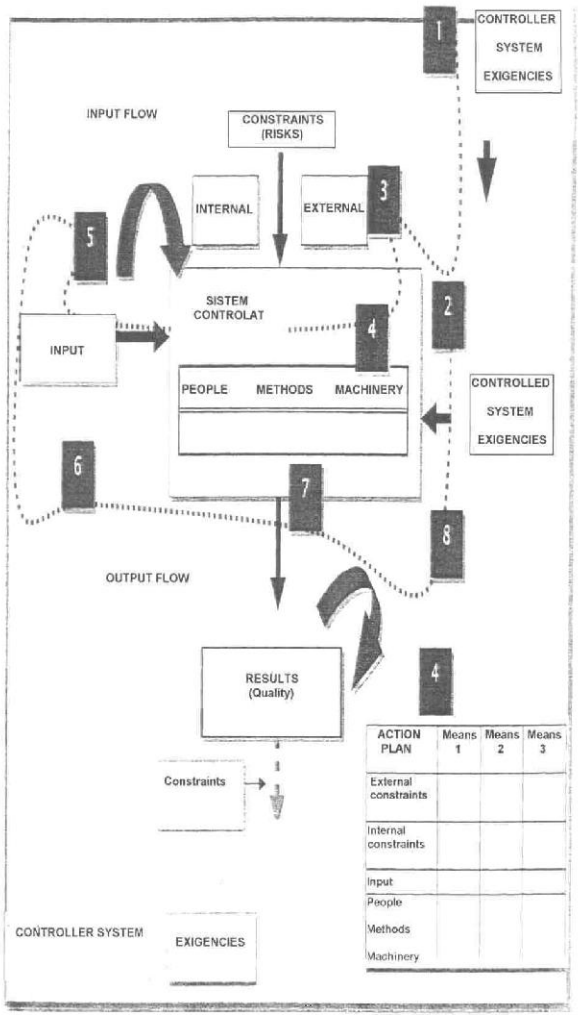

Fig. 1.10. Anticipatory systemic model

4. ANTICIPATORY MANAGEMENT MODELS OF THE ARHEMIC RECONFIGURED HUMAN RESOURCES

The structure of the power system management models appealing to the human resources with minimum vulnerabilities steeped in the following original approaches:

-The hope model based on the features of the human resources and of the wish of the human factors to be compensated up to the level of expectations. The condition for applying this model refers to the realization of productivity and

of the production along the entire design-operation path of the new efficient structures to which contributed the intelligence and diligence of the specialists involved.

-The model of equity starts from the motivation that each place of production.

-The model of the creative potential in which intellectual and physical pollutions tend to zero (processes without vulnerabilities).

-This model appeals to the application in the process management the human resources that offer the human factor an intellectual challenge of the mode of selecting the decisions based on the evolving calculation.

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The mathematical structure of these models in the operational research holistically applied includes the following real costs:

$$M^{depth}_{protection\ model} = \left[M_{SER} + M_{investments} + M_{operating\ reliability} + \right.$$
$$\left. + M_{competitional\ market} + M_{anticipating\ vulnerability} \right] \quad (5\text{-}1)$$
$$M_{reconfigured\ power\ system} = \left[C_{DD} + C_{CC} + C_{SS} + C_{RU} + C_{EF} + \right.$$
$$\left. + C_{DC} + c_p R_{SER} \right]$$
$$M_{sustainable\ development\ investments} = \left[I_{DD} + I_{CC} + I_{SS} + I_{RU} + I_{EF} + I_{DC} + \right.$$
$$\left. + c_p R_{tINV} \right]$$
$$M_{operating\ reability} = \left[C_{innovative\ information} + C_{economic\ state} + C_{quality} + c_p R_{SFT} \right]$$
$$M_{competitional\ market} = \left[C_{spot\ market} + C_{virtual\ market} + C_{public\ relations} + c_p R_{PC} \right]$$
$$M_{dwindling\ vulnerability} = \left[M_{risk} + M_{catastrophe} + M_{chaos} + c_p R_{rch} \right]$$

Where: C = sustainable development costs (C_{DD}) and the commercial ones (C_{DD}), the production (C_{SS}), the reconfiguration of the human resources (C_{RU}), including the economic and financial activities and the decision ones (C_{EF} and C_{DC}) C_p = the penalty coefficient of the restrictions on the domain of operațional research R.

The model of anticipating the reduction in vulnerabilities (risk, catastrophe, chaos) includes approaches of computer training of the human resources, approaches regarding the implementation of laboratories of optimizing the ergonomy, approaches for a continuous redesigning of the working posts, and efforts for the development both of the man-computer dialogue and the incentive to diligence (physical, intellectual) of the human being reconfigured in the idea of reducing the vulnerabilities beforehand.

The training of human resources with special performing and managerial - entrepreneurial abilities began in the-National Power System by founding and developing an enterprise Antoprocentrice that uses European funds to better the workers within the National Power System. Thus, in the National Power System it is provided to lay off about 15000 employees until 2035 without affecting the profitability.

Reconverting this human potential aims at preparing and selecting the workers in the NPS in order to point out the abilities with models of the form:

- The model of professional knowledge emphasized by tests specific of each class of new entrepreneurial activities.
- The model of improving the working conditions as a premise of increasing lab our productivity and diligence.
- The model of the creative potential of lab our performed according to vocation (intelligence, creative ideas, pragmatism, a new outlook on lab our open to consumer, promoting software engineering, preoccupations for developing the career and accepting wages based on results that generate excellent profits. In the case of entrepreneurial managers apply to the following tests: integrity tests, intelligence tests, and maturity tests. These tests emphasize the quality of the new managers required by the assurance of success of the unit due to credibility, anticipation of vulnerabilities, development of technological and managerial success stages, training of efficient teams of work generating profit and quality from the economic and financial aspect along the entire power production - consumption.

5. RECONFIGURING PECULIARITIES FOR THE HUMAN RESOURCES IN THE INSTITUTE FOR STUDIES AND POWER ENGINEERING

The main reconfiguring peculiarities for the human resources at the level of designing the power objectives can be emphasized by pointing out the following significant aspects:

- Including the personnel activities in the structure of the operational researches and turning to the schedule in computer assisted network under the leadership of a manager specialized in training design engineers who build a highly efficient career.
- Reconfiguring the direction of human resource management according to the following strategic requirements: empathetic training by intensive professional courses in order to train vulnerability prevention managers, managers with a sense of the future of the design unit, managers of business specific of design in collaboration with European specialists, specialists in innovative normative forecasts, personnel with preoccupations for the real modeling of trade activates, project managers with opening to power objectives computerization, trainers of sustainable development teams, computational market specialists, managerial innovators of technology, power quality and power processes implementations, designers of product prices and trainers of decision makers with entrepreneurial abilities opened towards establishing at the level of the unit of a new organizational conception and culture.
- The application in ISPE of the ergonomic strategy for increasing productivity by removing nonproductive time and stress, designing ergonomic workplaces from the point of view lighting, from the point of view of using computer technology and from the point of view of creating the best environment for teamwork.
- Developing the creative potential of the human factor as regards the extension of software engineering, the building of a new attitude to work by applying the convergent engineering within project management.
- The amplification of the exchange of specialists in ISPE with specialized design units in the European Union and the organization of an interdisciplinary training of the young generation by master, doctor's courses, and by post doctor's schools.
- The designing of a testing laboratory for the abilities of the personnel employed in ISPE and checking the quality of the human factor in collaboration with the relevant universities in this country and abroad.
- Creating professional collaboration platforms of training the new specializations that meet the requirements of

the European Union in the field of power objective design.
- The training of the research teams that give impetus to the sustainable development of the Romanian power sector, by calling in European structural funds.

The mathematical modeling of these peculiarities and their application within the Institute for Studies and Power Engineering (ISPE) will be tackled in a new article that will be published in a future issue of Buletinul ISPE.

6. CONCLUSIONS

The human resource reengineering of the National Power System has to be carried out by empathetic models (intensive laming), ergonomic models allowing the design of computer assisted workplaces and by the entire redesigning of the posts (rating, salaries according to results and productivity).

The risk due to lack of training of the human resources can lead to catastrophe and chaos, which practically can exceed in knowledge and application the Hammer conception of training managers and operators in a power system subject to original changes.

The training of the new generation of specialists and senior teams that work in ISPE according to the coordinates of the new transformations have to be carried out by a more intensive academic training (master and doctor's courses both in this country and abroad), by improving the abilities of using the efficient computer systems and by stimulating the creativity with adequate salaries that can be covered with special results in work.

The approach and realization of the expert and neuroexpert computer structures destined to the reduction in the holistic vulnerabilities is a new Romanian experiment in the field of economic and engineering reconfiguring of the human resources with a view to attaining the performance required by the integration of the National Power System in the European Power System.

The responsibility of energy solution depends on ensuring the quality of human resources and especially the arhemic trained human factor trained arhemic is responsible; this result from the bunch of new ideas on the professional training of specialists in the field of energy.

In order to sustain the reconfiguring of the human resources in România we work at the elaboration of the legislation in the field of professional education and we passed to the reconversion of the specialists laid off in order to train human resources according to the new domains required by the computer assisted operational research.

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