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Resilience Governance through Serious Energy Gaming

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Abstract

Physical analogies emphasizing cooperative behavior in systems are explored and integrated into so called 'serious energy games', to contribute in a better understanding, monitoring and good governance of some of the complex security issues confronting the evolvement of contemporary energy systems. It is believed that such exercises might be supportive in the necessary attempt, by the many stakeholders and actors / agents involved, to bring balance to prevailing policies of which seems to be "Go change yourself - in a resilient fashion!" An extrapolation of several findings to other than energy systems tempted to implement drastic changes based on substantial substitutions - hardware, software and mindware - under relatively short time horizons cannot be ruled out.

Keywords: serious gaming, resilience

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1. Introduction

The *Energy and Climate package* adopted by the European Council in March 2007 (v.e.g. EC Environment, 2010), requiring the EU region to reduce, by the year 2020, its greenhouse gas emissions by 20%, increase the share of renewables in energy consumption to 20% and save 20 % of total primary energy consumption is perceived by many analysts and voices from the public as *the* most outstretched ambition the planning think-tank of the United Europe had ever set forth for the first half of this century. For what the official European policy wants is – *drastically change* the Energy System to, hopefully, adapt it to the 21st century challenges, yet make sure that the shifting realities thus resulting would somehow maintain a *permanently resilient* System, as the essence of *Energy Security*.

In this discussion we gloss over *vulnerability*, as a road to get a better grip on what *resilience* may imply, when thinking of a system under the heavy pressure of unplanned challenges and planned reformation. Epistemologically, we take a pragmatic way in sorting out *terms*.

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2. Quantitative Vulnerability Estimation

The term *Quantitative Vulnerability Assessment* (QVA) is a result of a warranted analogy with *Quantitative Risk Assessment* (QRA).

The QRA task is to take a well-substantiated *noun* (risk) to a number. The QVA task is rather to take an *adjective* (i.e. 'vulnerable'), reflective of a virtuality ('prone/open to…') to a number. And *that*, it is believed, is what makes QVA more 'qualitative' than the QRA - in the sense that capturing vulnerability may require more than a single correlation: it may take a *process*, reflective of the targeted system *behavior*, and echoing in a *pattern* that, in turn, may be expressed in equations and numbers.

In Statistical Physics is that all measurable, macroscopic property and /or behavior of a material entity can be explained by interpreting the motions within its microscopic model, provided the interactions between parts (intensity, effectiveness radius, anisotropies etc.) and parts susceptibility to external influences are properly set and described. The challenge of the attempt to build a physical analogy relevant to the vulnerability/resilience of systems such as e.g. the Electric Power system, or the Energy System overall is to (i) devise a conceptual machine working on measurable indicators, that (ii) would eventually emerge as the observable, macroscopic expression of the inner dynamics of its microscopic, many-body, counterpart.

It was shown (e.g. Gheorghe, Vamanu, 2004) that one possible macroscopic model for a system vulnerability metrics may be built on the following assumptions:

Assumption 1: One may see *vulnerability* as a system's virtual openness to lose its design functions, and/or structural integrity, and/or identity under the combined interplay of two sets of factors:

U- Internal, system-featuring factors; and

V- External, essentially management/governance-featuring factors.

All factors are supposed to be eventually quantifiable by appropriate indicators.

The U-factors feature the system part interactions, or exchanges - how intense, how far-reaching. The V-factors feature external influences acting upon the system and relate to system parts susceptibility to be affected by such influences.

Since both, the U and V factors may comprise a wide variety of indicators having little or nothing in common as far as metrics a solution is in order, to make all these underscored by a common, non-dimensional metrics allowing comparison. That takes one to the next assumption.

Assumption 2: System's measurable/monitored indicators (parameters) may indeed be aggregated such that two monitoring variables U and V are obtained.

One submits that U and V are membership functions of the fuzzy-sets theory approach to impact indicators [4]. Accordingly, if X_i , i = *1, 2, ..., n* are the normalized system indicators, then one may see U and V as some generalized Euclidian distances in the n-dimensional space of the indicators (Christen et al., 1995).

Assumption 3: Once U and V are determined, one theorize that these can make the aggregated monitoring variables of a two-state multi-component system. In Physics, the behavior of such a system is known as the *Ising Model*, covering macroscopic properties, stability issues and phase transitions in e.g. the ferromagnets, binary alloys, order-disorder phenomena and the like. Though no exact solution is available, a variety of approximations including the *Bethe-Peierls* solution, the *Bragg-Williams* solution, and the *Onsager* solution are currently curricular in the trade (v.e.g. Huang, 1963).

According to one of these, the membership fractions in the two-state system can be obtained on certain assumptions on the probabilities of individual transitions between the two states - as shown in the next section. The interplay of the actual, 'physical', and potentially numerous system indicators will result in variations of the aggregated parameters, U and V, which in turn will drive the system 'state' in- and out of a region of instability (see Figure 1).

In a conventional sense, an *operable* system may thereby appear as:

- *Stable*, and thereby featuring a *low vulnerability*;
- *Critically unstable/vulnerable*; or
- *Unstable*, and thereby featuring a *high vulnerability*.

Beyond these, the system may only be found *inoperable*.

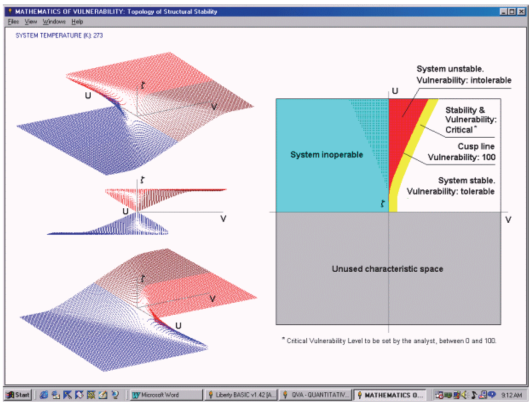

Figure 1. Schematics of the QVA machine. System's 'characteristic', i.e. the collection of real solutions of the 'equation of state' (1.1.6); see also (1.3.16).

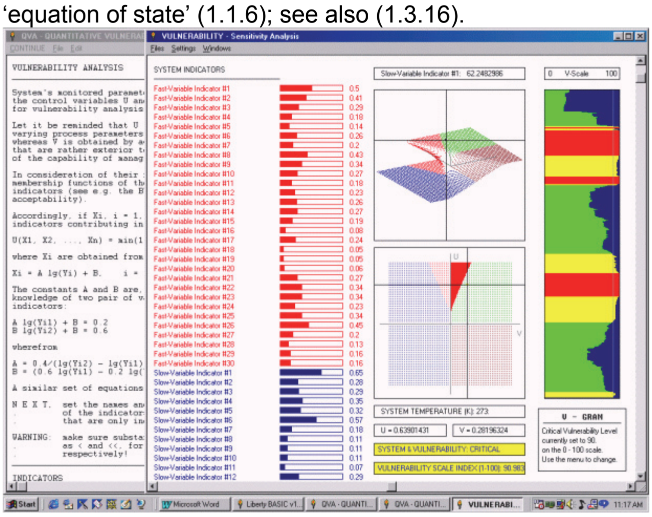

Figure 2. A computer-assisted QVA exercise. For the sake of the example, the system is described by 30 (generic) indicators of U-type, and 20 indicators of V-type. The variation of these, interactively performed by the analyst on acting the bars mid-screen (click-and-drag style) results in the aggregated variation of the U and V phase space parameters (cross-wires in the boxes near). The cross-wire follows the 'system state'.

Assumption 4: In consideration of the above, a 'Vulnerability Scale' may be defined, based on the assessment of the system state in the (U, V)-space. Obviously, such a definition is not univocal.

One possibility that was experimented on was to measure the *Vulnerability Index* by either the Euclidian distance, or the relative abscissa, of the state (U,V) to the cusp line in the U>=0, V>=0 region of the (U, V)-plane; and then normalize the index such that, everywhere in the cusp region, the Vulnerability Index be equal to 100%, that is - reach its assumed maximum.

In Figure 2, the 'V-gram' on the right is a histogram of the evolvement in time of the vulnerability, on the 0-100 scale, as defined.

The borderline of the cuspidal region, known as the 'characteristic' (Thom) is described by the equation:

$th((U\cdot\zeta + V)/\theta) = 2\zeta$ (1)
th standing for the hyperbolic tangent.

The region of the characteristic's topological foil featuring a single solution to the equation of state is the *region of system stability*, whereas the region featuring three solutions (of which only two are taken to have a physical meaning and can be accessed) is the *region of system instability*.
The following rough equivalence is assumed:
System Instability= Highest/Intolerable Vulnerability
System Stability =Lower/Tolerable Vulnerability.

3. On Resilience of Energy Systems

Let us now close in on the representation of the system as a collection of interactive parts subject to external influences.
Let $S(i)$, i = *1, 2, ..., M* be the variable qualifying the functionality of part i, $S(i)=1$ indicating a functional part and $S(i) = -1$ a dysfunctional part – which accommodates systems within the *Ising model* as observed in the preceding section (Gheorghe, Vamanu, 2008).
Let again be said that parts may switch from a functional to a dysfunctional state, and conversely, the process being assumed to be, in the final analysis, reversible, and *probabilistic* in nature.
Observant to the natural systems that are coherent enough - within their boundaries of definition - to feature a certain autonomy, or quasi-isolation of their own in respect with the remaining environment, the overall behavior of our model-system may be thought to be governed by *a variational principle*, applicable to system's total energy. According to such a principle, in a steady state of the system the individual states of the parts are such that the system 'energy',

$$E = -(1/2)\, \Sigma_{ij}\, \varepsilon_{ij}\, S(i)\, S(j) - H\, \Sigma_i\, \mu_i\, S(i) \qquad (2)$$

is a minimum for any given *temperature*.
The first term in Equation (2) denotes the total *internal* 'energy' of the system of the parts exchanging an 'energy' ε_{ij}, $i = 1,2, ..., M, j = 1,2, ...,M$, whereas the second term features the total 'energy' imparted to the parts by their coupling to the external, compelling 'field' H.
Physicists will immediately note that, in a textbook rendering of an Ising or a Heisenberg model – that are at the origin of our analogy - the normal assumption is that both the coupling ('exchange') energy, ε_{ij}, and the field-coupling constant, μ_i do *not* depend on the individual parts *i, j* – a fact that has to do with the assumption that all parts are identical (and in effect indiscriminate) to each other. In this respect, Equation (2) is a generalization to a many-body system of *non-identical* parts, the validity of which owes to the fact that, in effect, our ε_{ij} expresses the strength of a *connectivity* between parts.
In applying the notion above, note that any part-*i* state-flip (from functional, 1, to dysfunctional, -1, or vice versa) entails a change in system's energy, of

$$\Delta E = - S(i)\, (\Sigma'_j\, \varepsilon_{ij}\, S(j) + \mu_i H) \qquad (3)$$

where Σ'_j indicates a sum that, in practice, extends over a certain neighborhood of part *i* – although in principle it may extend over *all* the parts other than *i*.

Following the Ising model philosophy (see the discussion in references [7-8]), a part's behavior is governed by the following set of rules, consistent with the assumptions above:

Rule 1: If $\Delta E <= 0$ (i.e. taking system to a lower energy), then the part would always undergo a state-flip.

Rule 2: If $\Delta E > 0$ (i.e. taking system to a lower energy), then the part flips only with a probability

$$P = \exp(-\Delta E/(k_B T))\,, \qquad (4)$$

with T a 'system temperature', and k_B a 'Boltzmann constant', conveniently taken as 1.

In practice (see Sprott [10]), a *Metropolis algorithm* (Metropolis, Teller, Rosenbluth, see also [9]) is recommended for the implementation of *Rule 2*. It reads:
Let r be a random number between 0 and 1.
Then,
if $r <= P$ (P given by (4)) then *do* flip;
else, *do not* flip.
Under these terms, for any 'temperature' T there will, in principle, be M_1 system parts that would be functional and $M_2 = M - M_1$ parts that would be dysfunctional, so that one may again define a *system performance fraction*, ζ as:

$$\zeta = (M_1 - M_2)/(2M). \qquad (5)$$

Definition (5) places performance fraction ζ between (-0.5) and (+0.5), and favors the following assessment rule:
- a system featuring $\zeta >= 0$ is *mostly functional,* whereas
- a system featuring $\zeta < 0$ is *mostly dysfunctional* .
And the value-judgment placed on a system management policy/strategy relates to *an assessment of the extent the system is kept mostly functional.* Like in the interpretation given in the preceding section, the *macroscopic* behavior of a system, normally expressed via variations in a number of indicators of definition perceived as relevant, appears a result of system's *microscopic, co-operative* behavior, the macroscopic echo of which is the performance fraction, ζ.
To further explicit this relationship let it be noted that, assuming $S(i)=1$ and performing the sum Σ over M_1 -1 terms $S(j)$ equal to 1 and M_2 terms equal to –1, and in consideration of the definitions (10), or (26), of ζ, one has:

$$\Delta E= -\varepsilon\,(M_1 - M_2 - 1) - \mu H = -\varepsilon\,.2M\zeta - \mu H = U\zeta + V \qquad (6)$$

Similarly, for $S(i) = -1$,

$$\Delta E = \varepsilon\,(M_1 - M_2 - 1) + \mu H = \varepsilon\,.2M\zeta + \mu H = -(U\,\zeta + V) \qquad (7)$$

Here, since ε is the exchange (pairing) energy for any pair of interacting system constituents, $U = 2M\varepsilon$ relates to *the total interaction energy of the system's parts* – a quantity featuring the *internal* dynamics of the system. In turn, energy $V = \mu H$ features *the coupling of parts to the external 'field' H*. The parallel with the U and V defined in the macroscopic theory is immediate.

Equations (6 - 7) provide a consistent interpretation of the microscopic, state-flip probability (4) in terms of macroscopic, *overall system transitions*. Thus, the probability of a system transition from an overall state characterized as (M_1, M_2) – i.e. M_1 functional and M_2 dysfunctional, parts, to an overall state characterized as (M_1-1, M_2+1) is

$$P_{12} = exp(-(U\,\zeta + V)/(k_B T)), \tag{8}$$

whereas the probability of a system transition from an overall state characterized as (M_1,M_2) to an overall state characterized as (M_1+1, M_2-1) is

$$P_{21} = exp((U\,\zeta + V)/\,/(k_B T)), \tag{9}$$

With the aggregated variables U, V, T and the probabilities thus defined, the gap between the microscopic vision of the system in this section and the macroscopic vision adopted in the preceding sections is now completely sealed, and the Statistical Physics protocol requesting a microscopic substantiation of the macroscopic, phenomenological models is observed.

The process described can be numerically simulated for any, generic, system of parts. The algorithm induces in the system the afore-described microscopic transitions, under the logics of an asynchronously-refreshed collection of cellular automata, cyclically stressing the system by external fields coupled to the parts. Such stress tests give the system performance fraction ζ as a function of the applied field H (Figures 4-6).

Observing the response of the system one immediately notes its reactivity, or otherwise tendency to antagonize the drift imposed on it from the outside. In plain words,

- If a system is dominantly functional then it tends to maintain its level of functionality (performance) in spite of applied stresses threatening to make parts dysfunctional;
- If a system is dominantly dysfunctional then it tends to maintain low levels of functionality (performance) in spite of the applied stresses attempting to make parts functional again; and
- The transition from a dominantly functional to a dominantly dysfunctional system, and vice versa, tends to be abrupt (as opposed to gradual) and essentially depends on system's 'temperature'.

Systems showing such a behavior are known as featuring a *hysteresis*.

One deems that the reluctance to changes in the level of performance under applied stress, of systems with hysteresis, is an expression of their internal coherence through interactivity and can be construed as **resilience**. (Gheorghe, Vamanu, 2008). In this interpretation, *a resilient system does not need to necessarily get back to its original parameters once the external constraint was removed – it has only to maintain a satisfactory level of functionality-as-per design while bearing with the changed, external conditions*. This, it is believed, may be a more decent and realistic demand than asking for a rigorous, mathematical system *stability* – a quality that would, within limits, take the system back to its initial condition.

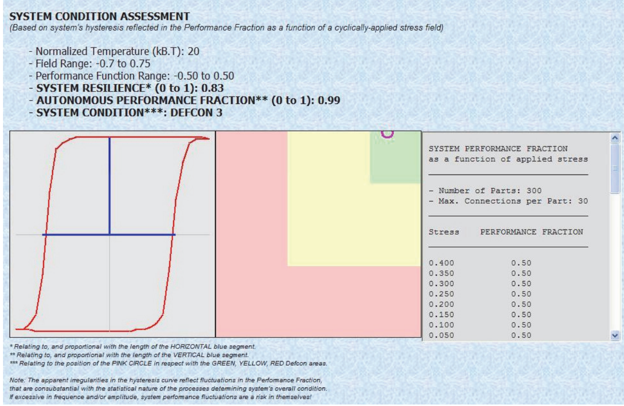

Figure 3. Hysteresis in a 300-part, 30-part links/part system, at a normalized temperature of 20 units: DEFCON 3.

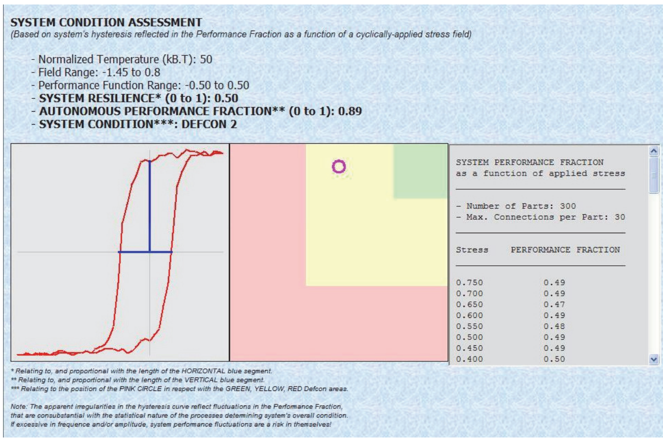

Figure 4. Hysteresis in a 300-part, 30-part links/part system, at a normalized temperature of 50 units: DEFCON 2.

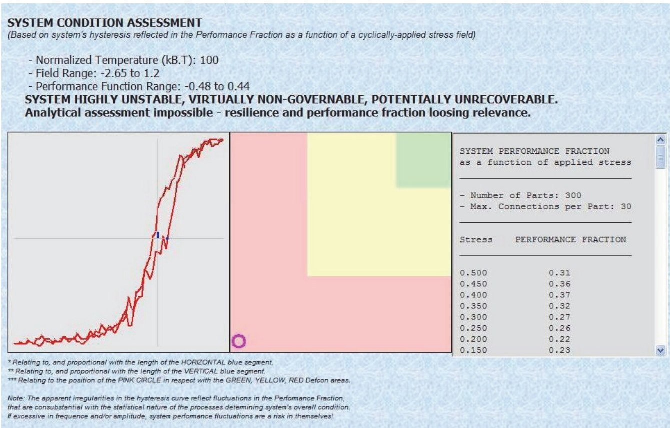

Figure 5. Hysteresis in a 300-part, 30-part links/part system, at a normalized temperature 100 units. System unstable, virtually non-governable and potentially unrecoverable.

One submits that, under the *adaptive* form of resilience described, a system can evolve and atune itself to, or at least tolerate, new operational terms cast upon him by the realities of its environment, while securing the delivery of the services it was meant for. The other face of resilience – the one relying on sheer ‘stability’ – is, by nature, *reactive*, revulsive to changes and, because of that – probably less sustainable in a reasonable long-term strategy.

These being said, a natural measure of the adaptive resilience turns out to be *the distance of the intersections of the hysteresis cycle with the abscissa* (see Figure 3). Expressed in units of the applied stress (field), this quantity may be termed - by analogy with the Theory of Magnetism - a '*Coercive Force*', or '*Coercivity*'. Further along the analogy, the maximum value of the performance function ζ, measured on the ordinate axis for a nil-stress may be termed '*Remanent Performance Level*' (v. '*remanent magnetization*', or '*remanence*'), although an alternative and perhaps more appropriate term in the context may be '*Autonomous Performance Fraction*' (APF). AFP would thus qualify a desirable feature of systems: their capability to sustain operations even when most of the incentives and/or subsidies, (financial, logistic etc.) normally required to set the system in motion have been tuned down, or withdrawn.

In such terms, a system deemed '*in good order*', or '*condition*' should display both

- a high *adaptive resilience* - indicating a good tolerance, or *absorptive capacity* (Cohen, Levinthal, 1990) for the effects of stress; and
- a high *autonomous performance fraction* - indicating an acceptable level of performance even in the absence of incentives/subsidies to maintain it.

This finding leaves one with the need to employ in the representation of the system condition *the Cartesian product* of the said quantities in an X-Y plane, one choice being to place the resilience on the X-axis and the APF on the Y-axis. This manner of visualizing/monitoring a system condition would immediately call to mind the defence drills that deal with readiness for appropriate response in threatening conditions in terms of 'DEFCONs'. In the context, one may, for instance, leave to the drill gamer the definition of boundaries between, say, three 'DEFCONs' of incremental degree of severity, the most severe featuring *the lowest system resilience*, OR *the lowest autonomous performance fraction* (APF). The conjunction - lowest resilience AND lowest AFP would then make the ‘worst-case scenario’.

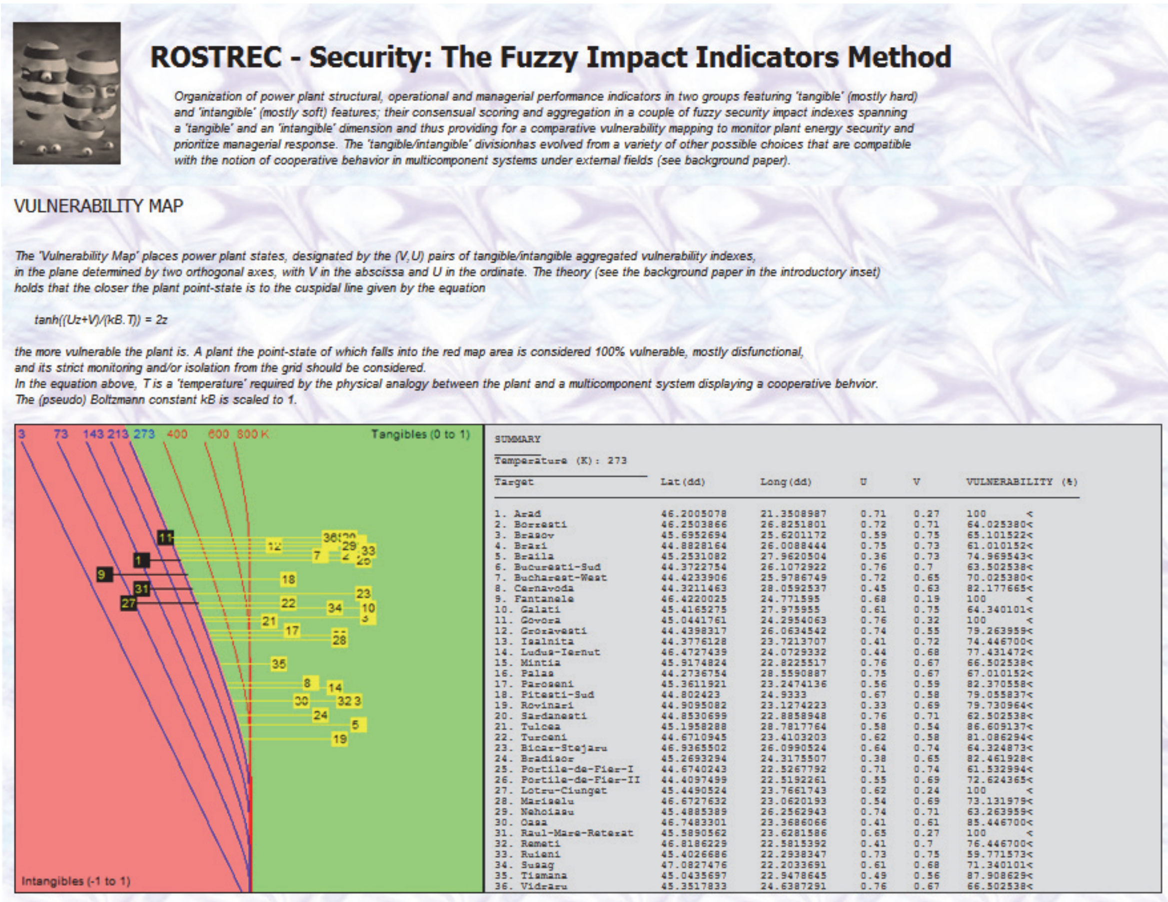

Figure 6. A vulnerability map of the power generation plants in a target-country.

4. Gaming on energy system strategies and Governance

Both the macroscopic and microscopic models described were, in actual fact, implemented in the guise of a web-based ‘serious game’, meant to provide graphic expressions to the proposed understanding of *resilience* and *autonomous performance capability* in systems (v. SDA Security and Defence Agenda (2010)).
Figure 6 illustrates an application of the *macroscopic model*. The table reproduces the segment of the interface listing the indicators selected for analysis – here grouped in ‘tangibles’ [T] (the U-type in model’s terminology) and ‘intangibles’ [I] (the V-type), on a perception according to which the ‘tangibles’ are more structural – and thereby slow-varying, whereas the ‘intangibles’ are more volatile and pervasive and thereby featuring faster variations and playing the influence agents.
Relating to the data in the table and introduced as a ‘vulnerability map’, Figure 7 places in perspective the vulnerability condition of targeted system’s parts – here the power plants in the generating system of a given country. A continual monitoring would make such synoptic a potentially helpful ‘dashboard’ for system managers and planners. A distinct module was dedicated to implement the microscopic vision, with a more explicit emphasis on the hysteresis effects and the interpretation given, in this context, to the notion of adaptive resilience.
After some enduring experiments with changing coupling constants, susceptibilities, and temperature one may end up with a 'feeling' on how systems with hysteresis behave. Here are the chief findings.

The facts that every intuitive observer will expect are:

- *Large* and *internally coherent* systems tend to show *a higher adaptive resilience and APF* and thereby *a higher-grade condition* in comparison with small, poorly-coherent systems, and also feature *more stable (fluctuation-free) operation regimes*. That would validate the integrative features provided for by the EU’s 20-20-20 initiative: higher grid connectivity; redundancy; power highways, shared structural (e.g. ITC) and operational standards etc.;
- Systems subject to poor/negligent/lax management/governance in terms of maintenance, monitoring, updating, corporate spirit, truthful self-assessment, ethics, as well as unfair business climate etc. - which translates as 'disorder', or '*higher temperatures*' show *degraded resilience and/or performance fractions*, down to complete collapse. Without prejudice, this aspect would mostly concern the EU’s newbies of later waves of accession, now still bogged down in what seems to be a painful, wobbling, asymptotic transition towards the Western reference standards.

Less intuitive yet not incomprehensible is the following finding:

Changes occurring, or forced upon the *strength of internal couplings* between system constituents are considerably more consequencial in terms of resilience and capability for autonomous performance, in comparison with the temperature-induced effects.

This aspect is definitely consequencial in regard with the substantive action core of the 20-20-20 EU initiative, which outstandingly requires an important volume of *technology substitution* as a vehicle to implement the sought policies.
Indeed, running the microscopic model under the assumption that a certain fraction of the traditional parts were replaced by new parts – hardware, software, management and mindware included - the exotism in comparison with the old being reflected in considerably weaker couplings with the ‘old guard’, (grid connectivity, load regimes, power traffic, other exchanges, compatibilities, interfaces etc.) would immediately result in changes in the hysteresis pattern and the consequent Cartesian product of *adaptive resilience* by the *autonomous performance fraction* (AFP) – the more dramatic the changes the more ‘exotic’ the newcomers are.

Thus, if one can bear with a simplistic and, probably, over-conservative reckoning according to which a 20% GHG reduction, plus a 20% of renewables in covering demand, plus another 20% in conservation would amount to, roughly, a 3-times-20%, i.e. 60% substitution in the technology pool serving EU’s energy system, one would be faced with the change in system’s response pattern and consequent resilience and AFP depicted in Figure 8.

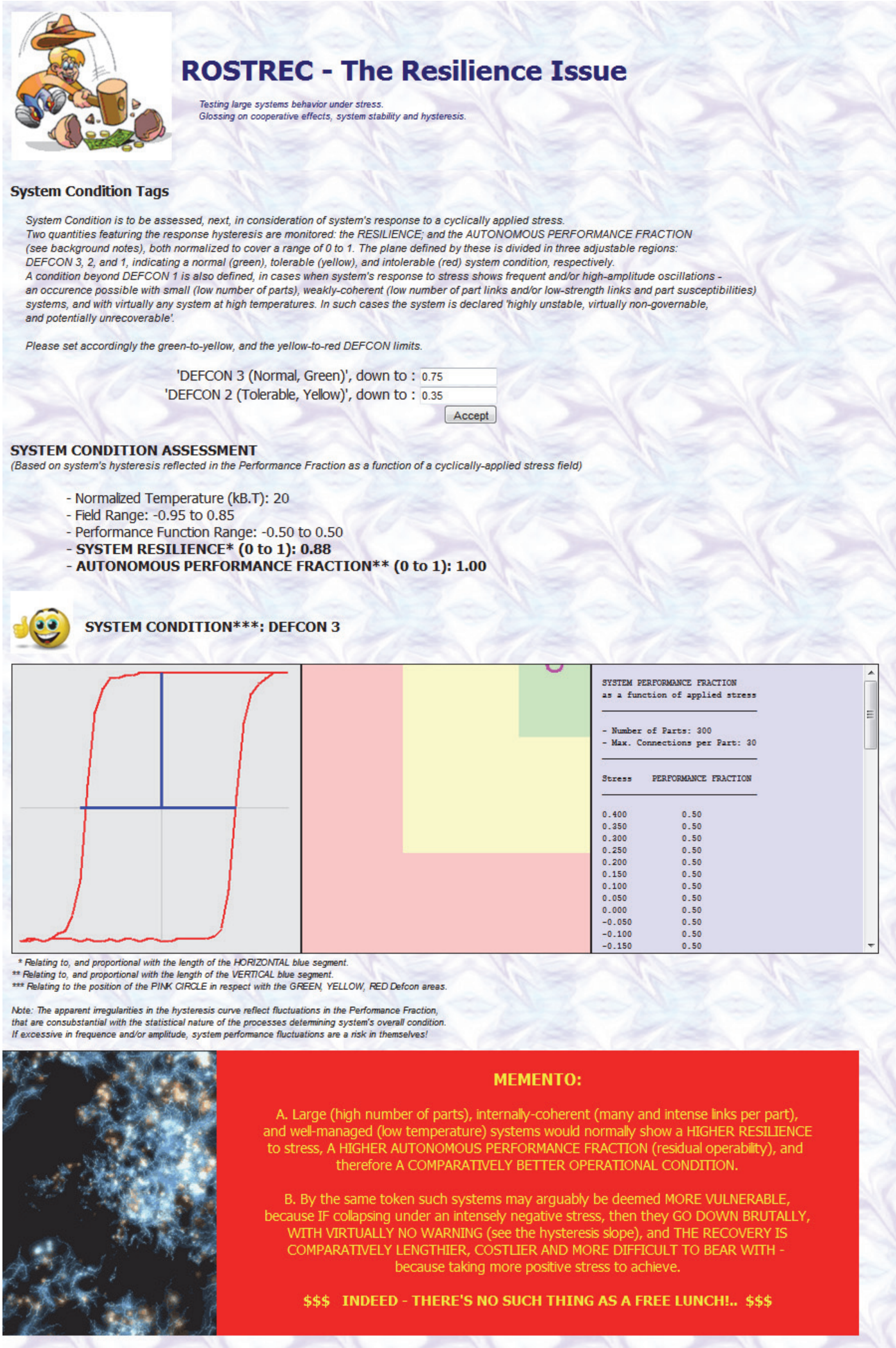

Figure 7. Interface web page, of an interactive game implementing the microscopic model.

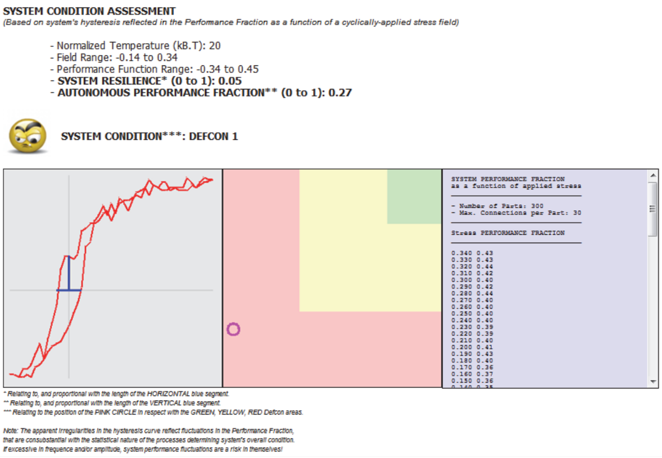

Figure 8. System response to cyclic stress (hysteresis pattern) for a 60% technology substitution.

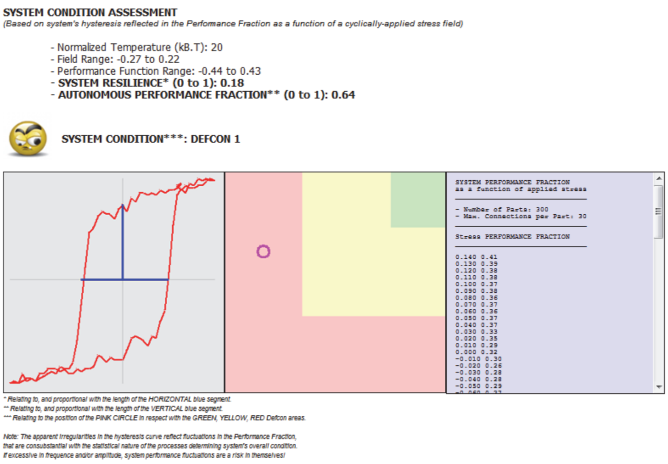

Figure 9. System response to cyclic stress (hysteresis pattern) for a 40% technology substitution.

Assuming that only two of the policy directives will be commissioned simultaneously, entailing a 40% technology substitution, the effects will look like in Figure 9.

Finally, if a prioritized timing for the implementation of the three directives would be considered, implying only a 20% technology substitution at any single step the situation will improve as shown in Figure 10. To be noted that numerical trials indicate that a mere rise in ‘temperature’, i.e. in the business and political climate may only marginally improve this outlook.

Finally, there may be also a speculative finding that is almost counterintuitive and, some may say, intellectually insulting, according to which *highly resilient and performant systems, that is - systems commonly appreciated as high-grade tend to be... unexpectedly vulnerable in* a specific, if odd, sense.

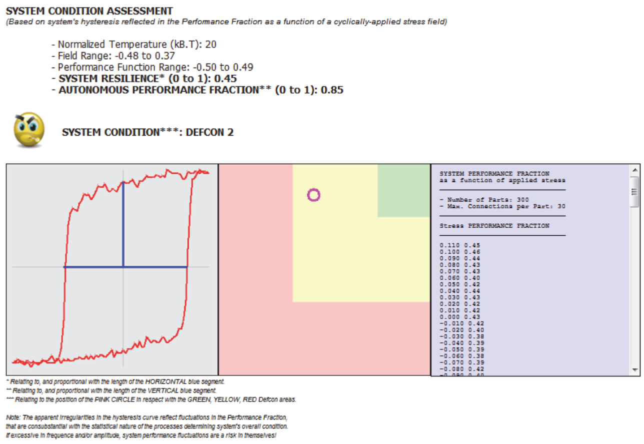

Figure 10. System response to cyclic stress (hysteresis pattern) for a 20% technology substitution.

This kind of vulnerability relates to the near-ideal shape of their hysteresis cycle (Figs. 3-10): quasi-rectangular, and covering a large expanse in the performance vs. stress (X-Y plan). For indeed, such a shape may encourage the foul feeling that 'things are all right' even if negligence, or external circumstances - like e.g. a prolonged recession - would take the normal, residual positive stress normally consisting of developmental and maintenance costs plus ‘facilities’, or ‘stimuli' (financial, logistic, intelligence, etc.) into the red, in the negative-stress realm, because, on the account of system’s internal, quality-interactivity (smooth operations) *even there the performance fraction is still on the higher plateau* - isn't it? Well, it is - *yet perhaps only for a while*, for the unsuspecting system finds itself dangerously-close to the precipice that, if reached by a mere further, apparently insignificant decrement or fluctuation in the stress level, *will take the entire structure down into a full-fledged collapse.*

Aggravating factors of such a perverse form of vulnerability are:

- *a virtually-complete lack of early-warnings on the imminence of a collapse* (system stands steady at a high(est) level of performance although its environment is clearly deteriorating);
- *the brutality of the collapse, if/when it happens* (v. the steep slope of the hysteresis) that would dramatize the entire scenario; and - perhaps equally important,
- *the remarkably long and costly way to a full system recovery* (see the length of the lower hysteresis cycle plateau).

And, in such a case, the only good thing about the bad things is that, if/when the recovery point – the lower-right corner of the cycle - is finally reached, then the ensuing process is expected to be swift and effective.

Should the obsessive disruptions of the century’s first decade – 9/11 and the Recession – be not with us, these authors would have been much more reluctant in giving such a speculation to print. Yet, can one *really* dismiss the thought that both developments were signs of a brutal descent on the left-hand slope of the hysteresis loop featuring *a highly resilient and performant, yet overconfident and oblivious of hidden faults, System*? And can one wave aside the suspicion that the apparent ineffectiveness of all that money pumped into the System by the Administration to stop Recession and assume the long-expected climb-up to better times is due to the fact that the turning point suggested, in a symbolic sense, by the Physical analogies – '*the lower-right corner of the hysteresis cycle*' - has not yet, in spite of all efforts, been reached?

Conclusion

As often observed, large and complex inanimate systems may have much in common with the living bodies. One may look at resilience like at cholesterol: like with the latter, *one needs a 'good'* (*adaptive*) *resilience, in a certain amount*, *as opposed to a 'bad'* (*reactive*) *resilience and, in fact, any resilience in an excessive amount*. Physical analogies popular not only in the trade itself, but also in such disparate fields like Biology, Physiology, Neuroscience, Sociology, Econometrics, Electrical Engineering and Electronics, the ITC, the Psychology may help one understand that the implementation of such ambitious a plan as 20-20-20, endeavoring to take EU to the next level as far as energy security via, virtually, a crash campaign in technology substitution - hardware, software, management, mindware and all - requires *a consolidated capability to withstand and absorb changes while maintaining performance by continual adaptation, one component of which is permanently securing* (*i*) *system's absorptive capabilities; and* (*ii*) *the acceptability of policies and their net effect on people.* The border between adaptive resilience and reactive resilience is not thin, as the saying usually goes – it is fuzzy. While modeling it is an ambitious task yet to be assumed, one may say with a sufficient degree of confidence based on casuistry (v.e.g. Iran's 'Westernization' in the 70s) that 'too much, too soon' is a certain way to failure.

Any progress in modeling complexities comes at the cost of a fresh cohort of new and perplexing questions. One of these, that is long with us by now is - *how much resilience is enough resilience*? That is – beyond what threshold a highly resilient and performant society gets oblivious of 'intangibles' such as the principles of good governance, management, ethics, work discipline and culture, moderation, and compassion for the lesser-adapted - on the account of the absence of early warnings that its transgressions are just about to be sanctioned by the blind, dispassionate justice of System Dynamics?

It is believed that reconciling the quest for sound, resilience-conscious changes *and* for an acceptable degree of stability; and implementing policies endowed with sufficient intrinsic warning features to prevent disruptive developments and setbacks may be *the* outstanding challenge that the governance bodies, in Europe and elsewhere, are facing, in the decade to come.

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