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Opinion

Information-Driven Innovation in Energy: Toward Sustainable Models for Energy Patent Start-Ups

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Abstract - In modern economies, especially in the EU, one of the main ways to finance and launch innovative businesses is through regulations regarding start-ups. This route seems problematic for some new patents, particularly in the energy sector when they require an experimental phase, being based on conceptual projects. Below we briefly reflect on some possible reasons for this problem and highlight aspects that could be useful for improving the regulation, so that it can facilitate the financing of the necessary experiments (or industrial prototype development) and therefore effectively promote innovation and sustainability possibly in a framework of ESG Management.

Keywords - Start-up; Investment; Innovation; New Ideas Experimentation; Patents; Conceptual Projects; Sustainability; ESG Management; Life Cycle Cost (LCC); Total Management Cost (TCM); Systemic Value Cost (SVM); Start-up Financing; Industrial prototype development.

1 Background

Observing the IPI (*Information Physics Institute*) from the outside and from the inside (as an associate member), it appears to be an organization that, although it is specifically aimed at information physics and the great themes of physics in general, is well anchored to the practical and industrial reality, having produced notable works for concrete applications [1]. This link between theory and practice that the IPI promotes and applies is fundamental for innovation and therefore for sustainability. Furthermore, one of the parameters - although not codified into norms - on which Start-ups seem to be judged and therefore financed, is precisely the qualification, capacity and experience of the team that a start-up is composed of. In this way, the IPI becomes the ideal place for the training and implementation of technical-scientific teams intended for innovation. For this reason, this has suggested presenting, for publication, a reflection, albeit personal, on the problem of patents and their financing.

Generally speaking, the abandonment of a patent can occur for various reasons, including:

1) High maintenance costs, especially in the first years after licensing.

2) Difficulty in finding funding for the development of the industrial prototype.

3) Negative evaluation of the commercial potential of the invention.

Reflecting on the topic here set forth as the object of this work and through concrete cases, some of which personally experienced, the conjecture may emerge (on which there is some precise and undeniable evidence, but not citable for reasons of confidentiality) that Italian legislation in this regard privileges small projects, immediately executable, rather than medium or large medium or long-term projects. In short, one has the impression that the short term is privileged, leaving the long term to large corporations only, given that in the free EU market the entrepreneurial intervention of the State is poorly tolerated.

This work took motivation from a review and expansion of a commentary - presented to AICE.ICEC Scientific Commission - on the research: *"The contribution of activity theory to modeling multi-actor decision-making: A focus on human capital investments"*[2] conducted at the "*Department of Social and Developmental Psychology, Sapienza University of Rome, Rome, Italy*".

This review is also motivated by the objective difficulties that are encountered in practice in the attempt to finance innovative (energy) projects, especially when they are conceptual projects not accompanied by all the design engineering for the related apparatus, which would allow the construction of a production plant and therefore the industrial exploitation of that specific conceptual project. In such cases, in fact, between the innovative idea and the construction of a specific production plant, there is the need for experimentation, essentially technological, linked on the one hand to verifying the correctness of the innovative idea and its concrete development; on the other hand aimed at the optimal design and construction of a prototype that functions regularly for industrial use.

2 Discussion

In the past decades, the innovation sector and therefore new investments in the industrial production sector in general, has been characterized – especially in the energy sector – by the concept of *proven technology*. This concept was intentionally expressed, even in requests for technical offers for investments in new plants, in order to limit the risks on technological innovations. For this purpose, proven technology was defined as a production technology that had successfully passed continuous operation for at least 8000 hours/year with unavailability factors for out-of-services (even for simple *Operation & Maintenance*), limited to a few percent. In the same period, directives were issued at EU level, also implemented at national level, which guided the choice of the best technology BAT (- *Best Available Technology*) in order to align with the IPPC (- *Integrated Pollution Prevention & Control*) criteria [3].

But it would not always be possible to adopt the proven technology criterion in investments in a society that aims at exogenous growth models of the Solow-Swan type, that is, at long-term economic growth models essentially driven by innovation in the short term; since this would be in contradiction with the fundamental assumptions implicit in the model itself. Such models, in fact, attempt to explain long-term economic growth by observing capital accumulation, labour or population growth, and productivity increases largely driven by technological progress. Ultimately, growth is basically the result of the efficiency of production processes and technological innovation.

New ideas in any sector can generate innovation, but they usually carry risks, precisely because they have not been used in the past and there are no valid examples to evaluate them. However, new ideas are currently produced by human beings who develop them and propose them for a practical socially useful application. Therefore, it has been rightly considered that investing in Start-ups is essentially an investment that, as it expresses great trust in the idea and in the person who developed it for a purpose, can be assimilated to an investment in human resources (essentially attributable to the inventor and only rarely to a few others associated with him).

The profile of the inventor, thanks to today's IT technologies, can also be traced quite well for implicit aspects (e.g. economic, patrimonial, cultural, scientific, psychological, social, regulatory, disciplinary, etc.). Certainly such a profile has value for the public or private investor, who is usually an organization and/or person with a high propensity for risk, capable of risking their own assets and income in order to see their capital invested in the Start-up and the New Idea bear fruit. But, the public or private investor is also an evaluator of the investment in all respects, very expert in the perception and appreciation of risk to limit it, taking into consideration - in the short, medium and long term - all the concrete aspects (tangible, measurable, assessable) and also the conceptual, psychological, meta-psychological and even meta-physical ones (therefore intangible, non-assessable, non-measurable, elusive).

If we refer to the real case of innovative patents (except in the case of selling the patented idea), where the very existence of a patent implies a certain and serious selection on the validity of the idea, practical experience seems to indicate, however, that the final decision to invest or not in a Start-up and in a New Idea, is played on a discriminating point: that is, on the direct involvement of the inventor and on the ability of the inventor (single or collective, structured in the legal forms of the Start-up) to risk his own capital (intellectual, patrimonial and income) in order to see his New Idea realized. In practice, this is the real "price" that in general terms an inventor must pay to obtain "credibility" in the eyes of the public or private investor. The higher this sort of "equity" of the inventor (i.e. real risk capital) is, the higher the investor's propensity to share the risk with the inventor, thus accepting an investment in the New Idea and the resulting Start-up. All this implies the need for further analysis, and therefore possible research, on the concept of marginality of the investment with respect to the financial and income situation of both the investor himself and the inventor proposing the investment. If, ignoring income (usually necessary for living!), we refer only to the available assets, and we assume the following ratios:

$$R_{inv} = \frac{\textbf{Share of the investment held by the Investor}}{\textbf{Investor's Assets}} \tag{1}$$

$$r_{id} = \frac{\textbf{Share of the investment held by the Inventor}}{\textbf{Inventor's Assets}} \tag{2}$$

whereas:

- the role of Investor is reserved for banks and financial companies with solid and large capital capacity (therefore with $R_{inv} \ll 1$ usually small);

- while the Inventor is usually individual and can be anyone, often a person with high human capital, creative, enterprising, but "common" in the sense of belonging to any social and economic class, and not necessarily with particular capital endowments;

it can be noted that the formation of an "equity" sufficient to give credibility to attract investments on a new, but risky patent, is usually affected by a very high r_{id} value, and often such that $r_{id} > 1$. The situation thus becomes a structural asymmetry in which:

$$R_{inv} \ll r_{id} \tag{3}$$

This last situation (with substantially marginal investment for the investor and anything but marginal for the Inventor) necessarily leads to the assumption of debt risks by the Inventor and therefore discouragement of innovation. In this way patents are easily sold, or become obsolete or abandoned without any attempt to explore their innovative value.

Regarding the conjecture referred to at the beginning of this paper, in order to ascertain whether there could be any evidence that would transform it into a completely established fact (or at least easily ascertainable), bearing in mind the above, let's try to take a look at EU and Italian data that can provide reasons for patent drop-offs within their first 10 years of issue.

- Dataset 1 - Italian case (Source: Chat Gpt based on public sources such as UIBM and EPO)

a) *Categorization by estimated development capital*

Based on the difficulties related to industrial development, we can group patents into three unofficial but analytically useful categories:

Category	Description	Estimated capital per prototype	Examples
High investment	Complex technologies, often deep tech	> k€500	Medical devices, robotics, aerospace
Medium investment	Projects with moderate complexity	k€50 – k€500	Automation, mechanics, electronics
Low investment	Simple or consumer-ready products	< k€50	Tools, functional design, gadgets

Table 1

b) *Estimated dropout rates by category*

Based on industry studies and trends observed by incubators, technology transfer institutions and UIBM/EPO data, it is possible to estimate:

Investment Category Estimated	Estimated Dropout Rate (%) within 10 years	Main Motivation
High Investment	60–75%	High Development Costs and Fundraising Difficulty
Medium Investment	45–60%	Limited Access to Finance, Moderate Technical Risk
Low Investment	30–45%	Easy Prototyping but Low Profitability or Ineffective Protection

Table 2

c) *Patent renewal costs*

The annual costs of keeping a patent alive in Italy are progressively increasing:
5th year: €60

6th year: €90
7th year: €120
8th year: €170
9th year: €200
10th year: €230
From the 15th to the 20th year... up to €650

These costs can influence the decision to maintain or abandon a patent, especially for small and medium-sized enterprises or for inventions with uncertain commercial potential.

- Dataset 2 - EU Case (Source: Chat Gpt based on data: UIBM (IT), EPO (EU))

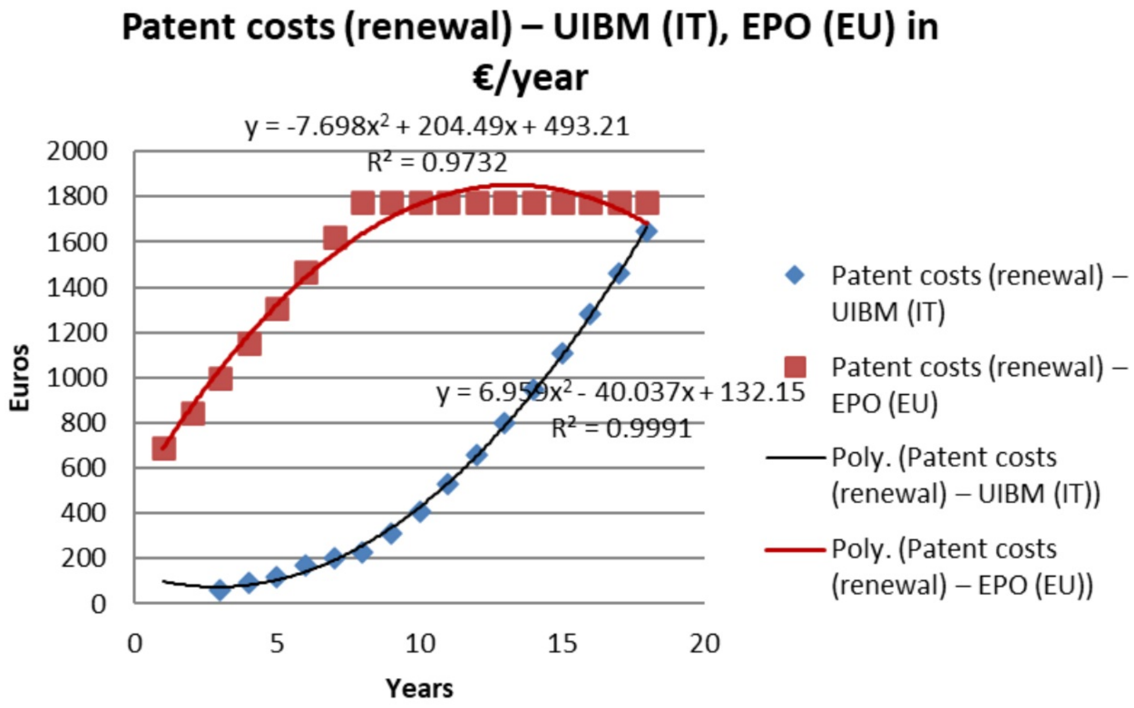

Figure 1

- Considerations on patent renewal costs in EU and Italy:

i) *Maintenance costs*: The renewal costs of European patents are significantly higher than those of Italian ones, especially in the first years after grant.

ii) *Abandonment rates*: Although no specific data are available for the EU, it is reasonable to assume that abandonment rates are influenced by maintenance costs and difficulties in finding financing for the development of the industrial prototype.

iii) *Incentives*: The introduction of fee reductions for micro-entities by the EPO represents a positive step to support innovation by small entities.

With a quick glance at Dataset 1 and 2, it is immediately clear that we are in a high entropy situation for innovation, and therefore a waste of human resource capital, intellectual capital and also capital in the broad sense, which occurs especially for those patents that are in a liminal situation between basic experimentation and industrial experimentation, since they concern new ideas and processes to be tested and therefore with high implicit financial risk.

A situation that makes of the new ideas and innovative proposals an almost exclusive sphere of wealthy strata of our society and in view of a limitation and marginalization of the middle class, can take on the characteristics of ”social exclusion” for some social groups with intellectual capital, but not economic-financial means. Finally, it is clear that the persistence of such a situation will allow innovation to an economy the more it is able to collectively assume the risk of innovation and of the individual patented ideas that support it. Ultimately this could bring to mind what N. Chomsky states in his essay on “Language and Politics”, when he speaks of the privatization of profits and socialization of losses in a capitalist society. The conjecture referred to here-above, seems to be transformed into a completely established fact, when and how much more one considers the rapid transformation into a listed company of a start-up just funded with high-risk innovative ideas. Risk that is thus downloaded to the public (through financing, guarantees, tax incentives or bailouts), while profits are concentrated in private subjects, often in an already “de-risked” phase. This dynamic is not inevitable, but is often encouraged by the system itself, especially when:

- Evaluation metrics reward expectation rather than sustainability.
- There are no public return mechanisms (e.g. royalties, golden shares, shared intellectual rights).
- The link between the initial public investment and the benefit for the community is lost.

Possible corrective measures, according to some observers, to rebalance all this could be:

- Shared intellectual property models in public projects.
- Sovereign innovation funds that retain equity and reinvest the profits publicly.
- Social impact clauses in early-stage financing.
- Golden share or public veto in critical sectors (e.g. energy, AI, healthcare).

So a “re-entry”, not only of a regulatory nature, of state intervention in the free market seems desirable.

Furthermore the following reinforcing elements should be considered as here outlined:

i) *Evidence*: The dynamics of public funding in Italy seem to be indeed oriented towards short-term projects, even if there are specific initiatives for long-term projects, but to a lesser extent.

ii) *Inexistence of an Institutionalized Algorithm:* There is no unified algorithm; the evaluation is done through multiple criteria and scoring schemes that vary from call to call.

iii) *Study of an Institutionalized Algorithm Proposal*: A model based on normalized and weighted parameters (cost, time, life cycle value, potential risk and team quality), with minimum thresholds and qualitative review, could represent a starting point to partially standardize the evaluation of fundability. For example in the terms following hereinafter (refer to Table 3).

If we were to formulate an algorithm ”to be proposed for discussion” that integrates the various parameters, we could structure it by assigning a weight to each of the identified parameters, as in the following table which has (at the moment!) only an exemplary value:

Input Definition			
Nº	Parameter Description	Parameter Symbol	Parameter Weight %
1	Estimated Total Cost: Investment required, divided into phases.	(TC)	20
2	Realization Time: Expected duration to achieve the first concrete results.	(RT)	15
3	Project Life Cycle: Long-term vision, including sustainability and evolutionary potential.	(LC)	15
4	Value Generation Potential: Estimated economic and social value created, including ROI projections.	(VG)	30
5	Technological and Market Risk: Risk assessment, with particular attention to innovation and competitiveness.	(TR)	10
6	Team Quality: Experience and skills of the founding group and collaborators.	(QT)	10
7	Total		100

Table 3

Each parameter can be evaluated on a scale [on which to assign (S_i) = for example from 0.0 to 1.0 based on predetermined criteria, thus receiving weight (P_i) according to their strategic importance, and to calculate the final score a formula of the following type can be used:

$$\textbf{Final score} = \sum_{i=1}^{N=7} (P_i \cdot S_i) \tag{4}$$

In parallel, the following should be defined:

- **Thresholds and Review Mechanisms**. For example:

i. - *Fundability Threshold*: Establish a minimum value (e.g. 65 out of 100) that the project must reach to be considered for funding.

ii. - *Qualitative Review*: Integrate the quantitative result with a qualitative assessment by experts, especially for elements that are difficult to quantify (e.g. disruptive innovation or potential social impact).

- **Iteration and Feedback**:

The algorithm (4) should be subject to periodic review and adapted based on feedback from investors, evaluation committees and the results obtained by funded projects. This would allow for continuous improvement of the system and greater coherence with industrial and innovation policy objectives.

These conclusions, although simplified and of first approach, could serve as a basis for discussion for a review of the current regulatory framework in order to mitigate the difficulties encountered for some innovative patents, open up more financing possibilities to projects of a more substantial size and develop more homogeneous and transparent tools for evaluating innovative projects in the start-up sector.

Finally, it is worth highlighting some updated data on patents in Italy:

- In 2024, the Italian Patent and Trademark Office (UIBM) received 10,148 patent applications for industrial inventions, an increase of 7.4% compared to 2023. 9,027 national patents were granted, of which 7,532 for industrial inventions and 1,273 for utility models.

- Validations of European patents in Italy were 20,821, a decrease compared to previous years, mainly due to the adoption of the European patent with unitary effect.

But what is reported above almost pales in comparison to what is reported below.

The asymmetry between "proof of concept" and "proof of market" (the former demonstrates the feasibility of a concept, while the latter demonstrates that there is demand for a product or service) touches a crucial point in the debate on energy innovation and long-term sustainability: the almost total absence of privileged and systematic channels for financing experiments with a high speculative and conceptual content, especially in the energy sector. In the field of energy production – especially with frontier technologies (nuclear fusion, LENR, cold fusion, etc.) – the distance between theoretical concept and industrial prototype is enormous, and almost always out of reach for normal public and private financing channels.

The EU innovation annual investments in the energy sector are included in the package of the total volume of investments for such a sector and may reach very high portion (even 70-80% or more).

Energy Investment in UE Time Series (2002–2023) - Billion €				
Year	**Italy**		**UE**	
	Public	**Private**	**Public**	**Private**
2002	2,5	3	25	35
2005	3	3,5	30	40
2010	4	5	35	50
2015	5	6	40	55
2020	6	7	45	60
2023	7	8	50	65

Table 4: Note: Values are approximate estimates based on available data [4] (via ChatGPT) and may vary based on sources.

From Tab. 4 above and Fig. 2 hereinafter, on the basis of Time Series it is possible a Trend Analysis of investment as follows:

i) *Italy*
- *Public Investment*: Steady growth, with a significant increase after 2010 thanks to policies to incentivize renewable energy and energy efficiency.

- *Private Investment*: Moderate increase, with an acceleration in recent years due to interest in green technologies and the digitalization of the energy sector.

ii) *European Union*
- *Public Investment*: Progressive increase, supported by programs such as Horizon 2020 and the European Green Deal.
- *Private Investment*: Significant growth, with a peak in recent years thanks to tax incentives and greater environmental awareness.

Proceeding in a comparative form, it can be noted that annual growth increases in a substantially linear way both in Italy and in the EU, but while for Italy the lines representing the increases overlap almost at a value of 50% public and 50% private with minimal divergence along timescale, therefore balanced. Instead, in the case of the EU the homologous lines diverge significantly, up to the point that a projection of the current trend to 2030 indicates that private investments will be prevalent (around a value of 57%) while public investments will be a minority (placed around a value of 43%). Furthermore, as shown in Table 4, the absolute value of Δ(Tot - Priv) and Δ(Pub - Priv) are destined to increase as the public and private investment increase.

In the following graph (Fig. 2), to account for the aforementioned divergence in the EU case, the trend lines that respond to the following best-fit equations have been drawn:

- for private investments (with determination coefficient R^2 = 0,9837):

$$\mathbf{y = 1.3821\ x - 2730.6} \tag{5}$$

- for public investments (with determination coefficient R^2 = 0,9934):

$$\mathbf{y = 1.1216\ x - 2219.6} \tag{6}$$

They may vary a little bit according to the best-fitting application utilised (e.g. EXCEL as in this case or others) but the variation is not significant for the descriptive intents of this work. Such equations may be utilised as a base for extrapolation, in order to obtain the possible future trend – if the present will not substantially change – and starting from Table 5 reported in the conclusions.

Today, funds are mainly oriented towards technologies that are already demonstrable, even if improvable (e.g. photovoltaic, offshore wind), towards modular and scalable projects with known business models; "incremental" rather than discontinuous innovations (which are often discarded as too risky or "visionary"). This certainly privileges the security of capital employment and the related remuneration, but at the same time this creates a paradox: precisely the ideas that could revolutionize energy sustainability do not find space in institutional or venture capital channels, except for rare exceptions (ITER on fusion, some EIC Pathfinder projects, etc.). And yet, there is no structured public policy in Europe, and even less in Italy, that: a) allows conceptual experimentation with reduced costs and technical support; b) admits acceptable failures in the name of the knowledge generated; that favors a pluralistic scientific evaluation, where counter- current concepts are not filtered based on theoretical orthodoxies.

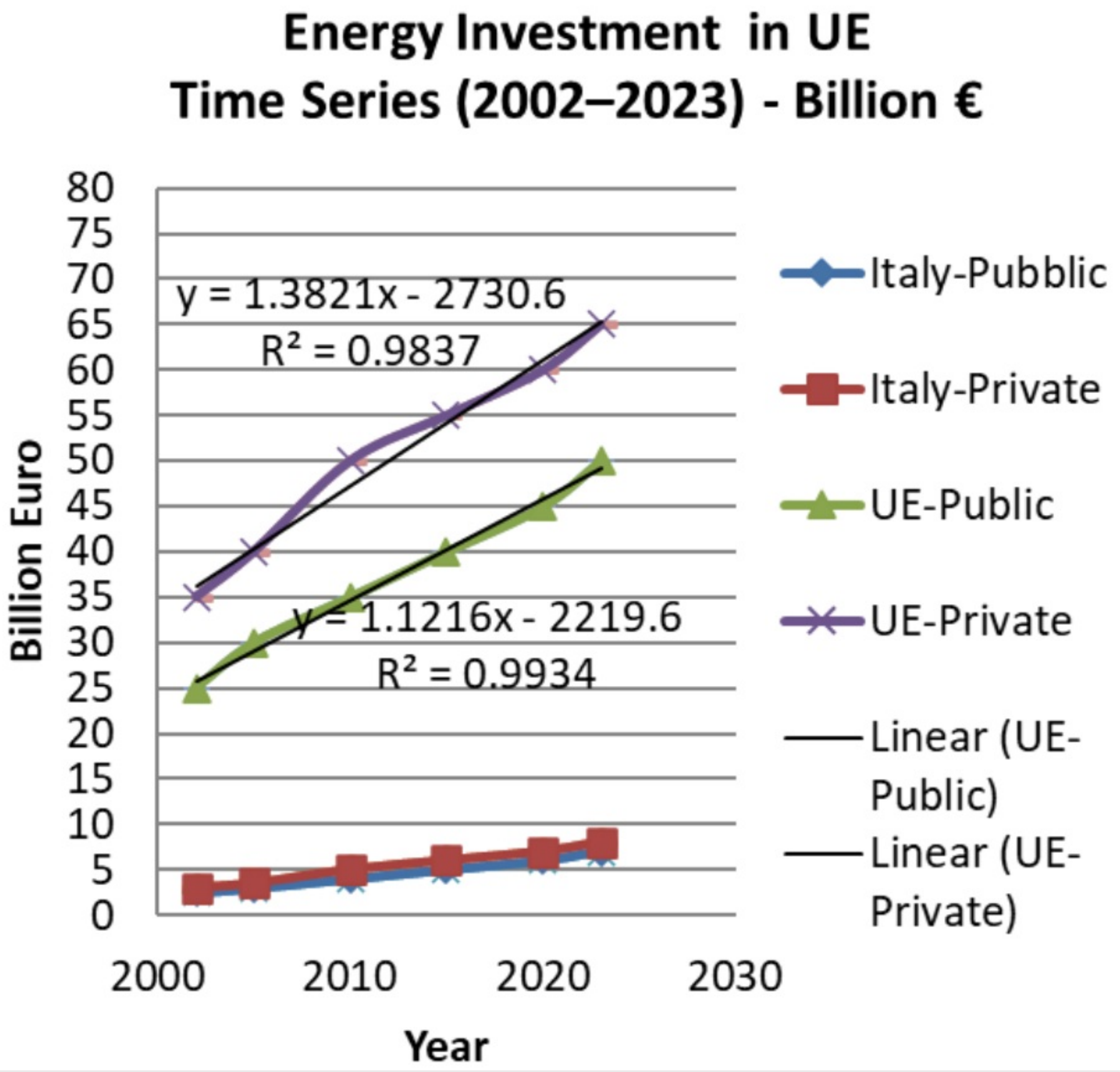

Figure 2

In practice, it is a systemic void. In other words: there is no "DARPA of conceptual sustainable energy". Sustainability, which everyone emphasize and sympathise while talking about it, presupposes energy as a systemic precondition, since sustainability is not a technology, but a paradigm. And energy is its founding key. Without abundant, clean, scalable and low-cost energy: climate solutions are partial (mitigation, but not systemic transition); global equity is lacking (differentiated access); and post-fossil development risks remaining a utopia.

3 Considerations on ESG sustainability management in the energy sector

Having discussed here innovative projects that carry inherent risk factors and having highlighted how caution in their financing can conflict with technological innovation and its sustainability, it seems appropriate to report some considerations with reference also to the related organizational and management criteria.

1. Since these are innovative approaches, which the current reality suggests are necessary, and since there are not yet concrete references unanimously recognized and accepted, it is necessary to consider that the ESG (Environmental, Social, Governance) approach of reconfiguring traditional management practices in a paradigm focused on sustainability, must be considered an iterative process - also influenced by "trial and error" type learning in the field - implementable in the long term and certainly not in the short term.

2. In the meantime, although the new criteria may provide a relevant framework, highlighting the interconnections between sustainability and organizational performance, they must necessarily be able to coexist with LCC (Life Cycle Costing), TCM (Total Cost Management) and even SVM (System Value Management) approaches, even if they have been implemented according to more traditional settings so far.

3. If, as is believed, the management principles and actions needed to promote corporate sustainability and develop ESG capabilities remain little explored, with existing literature addressing the topic in a fragmented way, this raises questions about the reasons that may lead to such a condition.

4. A sufficiently clear starting point seems to be a real and shared fact: There are no ready-made recipes for the implementation of ESG approaches. It is therefore necessary to try and if necessary try again.

5. Practical experience suggests that quite a few conventional or bold, very significant but complex projects do not come to fruition, not so much because of economic, financial, technological risks or a lack of conventionally understood planning. Rather, they fail because of a lack of political consensus, which reflects the absence of a social consensus, often also motivated by concern for environmental and political-social implications, whether authentic or manipulated, but in any case used as a tool of strong opposition that ultimately predominates, especially if accompanied by cultural and organizational deficiencies that push one to deviate from situations of equilibrium.

6. Sustainability is certainly a complex issue. A paradigm focused on sustainability requires evaluating complex phenomena to the point that one could even speak for the specific case of "Complexity Nestling" and therefore the need for holistic, multidisciplinary, systemic approaches. Sustainability presupposes the availability of energy and from here emerges that the requirement to achieve energy security is fundamental for ESG. For example, if we consider the concept of "Energy Poverty", if it were addressed (as happened in the EU) and not resolved, it could lead to serious environmental, social and governance difficulties. Furthermore, it is known that the extraction costs of any resource (photovoltaic, wind, tidal energy are themselves an extraction from solar, gravitational, etc.), throughout the extraction cycle - are linked:

- To the quality of the available energy (e.g. variability produced in power and frequency, regulation and control, availability of networks and their interconnection; see recent blackouts in the Iberian Peninsula);
- To the times of production, transport and use
- To the costs in all phases of the life cycle
- To the emissions, release into the environment connected to the extraction and costs of the relative externalities involved (for example carbon tax according to the EU ETS which is a complex system in itself).

On the basis of complexities nested one within the other as described above, it seems appropriate to take into account that complex systems are subject to chaos theories, which on a large scale (of different orders of magnitude, for example temporal or economic) can lead to unexpected cycles (due to the presence of "attractors"), to the point of speaking of "deterministic chaos", which may appear to be a contradiction in meaning, but at the same time can suggest through multivariate analysis the search for the relevant variables. The dilution along time for the achievement of objectives possibly set can lead to mitigation, but lengthens the necessary transition, and the path of the availability of time for an attenuation of emerging crises is not always concretely practicable!

7. In a broad sense, instability phenomena cause projects to diverge from what was planned.

8. Complex phenomena, when they become unstable and diverge, become chaotic. They are an indication of the presence of non-linear laws, which create bifurcation points typical of a situation of instability. Close to equilibrium, a deviation from stability can be reabsorbed with little expenditure of resources (e.g. energy properly speaking, manpower, or costs or time, ... in general!). But when one moves away from equilibrium it becomes increasingly difficult and phenomena diverge and become chaotic. Nonetheless, on a large scale they can give rise to cyclical repetitions that can be translated into real characteristic "laws".

9. Distance from equilibrium is not just a physical concept, but seems to be equally applicable, at least in an analogical sense, to every typical aspect of the ESG approach (corporate, political; social; environmental).

10. Speed of evolution in various field: technological; organizational; procedural (e.g. standards & permitting, QA, etc.); when the speed of evolution exceeds that of implementation, instability occurs and there is a greater exposure to divergence that can lead to a state of chaos.

11. Far from equilibrium, corrupt and predatory policies prevail, even far from any conventional concept of integrity.

12. Projects with identical content implemented in different environments do not necessarily reach the same result. From the comparative analysis of their history, possibly extended to more cases, significant suggestions can be drawn in particular by exploiting databases and employing artificial intelligence systems. (See for example what came out for planning Data Centers in Italy as reported in https://ipipublishing.org/index.php/ipil/article/view/147)

13. Although there is no evidence to prove it, it is reasonable to think that – as happens for the most conventional life cycle analysis (e.g. TCM and the less conventional SVM):

- the more ESG analyses and approaches are anticipated (e.g. from the early stages of development), the more effective they can be;

- the more any necessary corrective actions are introduced close to an equilibrium condition (i.e. close to original plan expectations), the more effective they can be without producing divergences from the equilibrium itself.

14. Questions on possible studies and research on the subject:

a) Can the ESG (Environmental, Social, Governance) approach of reconfiguring traditional management practices in a paradigm focused on sustainability be treated as a network of relationships between different entities of the most varied nature (organizational, economic, financial, technological, managerial, political, social, environmental, etc.) and therefore analyse them according to social network analysis techniques, perhaps also with the aid of AI systems?

b) If so, could further research be developed along the lines already outlined here: (see e.g. https://doi.org/10.59973/ipil.190)?

An innovative idea that generates an unfunded project actually makes such a project unsustainable. But this does not mean that finance and sustainability are synonymous or march together or that we can talk about a prevalence of finance over sustainability, or vice versa, since the problem is embedded in the framework of complexity.

The sustainability of the energy sector according to an ESG approach appears necessary to guide and facilitate innovation by financing the projects necessary for it, by preparing systemic and holistic development, evaluation and management systems, given the nesting of complexity in multiple aspects that can be considered. The research itself around these issues does not seem to be adequate and satisfactory in terms of volume and effectiveness. The issues raised above represent a necessary question given a stalemate in the energy transition, which causes a loss of credibility and consumes otherwise usable resources, risking distancing situations of equilibrium and resulting in instability that can lead to chaos.

4 Conclusions

It has been clearly seen, previously, how at European level a trend of substantial privatization of research and therefore of innovation seems to have been triggered, in contrast with a previous assumption that saw only industrial research as being of prevalent interest to private individuals and free enterprise. While basic and strategic research, especially if it fell within the scope of national interests, remained the almost exclusive prerogative of individual EU member states.
Ultimately, it cannot be said that the Italian and European regulatory framework, by limiting the role of State intervention in the financing of basic and industrial research, although it opens the doors to private financing and fundraising in any case, actually encourages innovation, especially in small and medium-sized enterprises that are swarming on the "*Peninsula*", but even in all Southern Europe. Furthermore, until yesterday the dominant mantra favored the short term, but today there are those who believe and affirm that "*in the short term there is no future!*". And it is true even literally!
To substantiate the conclusion above a look around could be enough considering the progressive and uninterrupted export of intellectual manpower to ensure them a minimum living, or even their diffuse unemployment, that in the best cases may end into precariousness or under-employment. Anyhow, at European level, investment in R&D is confirmed as a key factor in reducing intellectual unemployment and enhancing human capital. Nevertheless additional data and comments are outlined before in the Dataset 1, and Dataset 2, in which it is immediately visible:

- the discouraging role of cost to maintain a patent active along the years, after the concession from a State Organism;
- the structural asymmetry in financing experimentation of patents which are liminal between base and industrial researches;
- the clear evidence that patent abandonment is proportional to the economic-temporal dimension of the project and therefore it is the large projects rather than the small ones that are ignored;
- the short-term orientation seems to conflict with innovation, while the long-term orientation facilitates it; a crucial point in the relationship between innovation and economic-financial logics, founded and widely shared also in economic literature and in the world of policy.

Furthermore, the current regulatory framework negatively affects the employment of the intellectual workforce. According to data from the Inter-university Consortium Alma-Laurea, it seems possible to estimate an unemployment rate for PhDs between 5% and 11% (lower values for the EU and higher for Italy). It is a planned tendency of west civilization and not fruit of the case if the present public administration of a leading nation like USA affirms (through Spokesperson responsible) on X platform the need of electricians and plumbers more than indoctrinated Harvard laureate; while in Italy vertexes of Confindustria warns the youngsters not to study to much in order to easily find a job.

A fact that emerges from some concrete cases, which leads to the affirmation that among the difficulties there is also: "the absence of an adequate experimental body or institution", since:

- on the one hand, a free private financial market, which lives on interests, is ready to finance risky research projects that require experimentation, but demands the return of the capital, including interests, whatever the outcome;
- at the same time, universities and research institutes (public and private) are not willing to experiment with patents that imply a high risk because they are not covered by such risk, if they do not find an institutional way willing to guarantee it (and this coverage is expensive and difficult to obtain immediately).

Last but not least, the lack of a privileged way to finance the testing of patents concerning energy production based on the innovative concept and not on the basic design, with innovative methods (for example, nuclear fusion, with any method of confinement, such as LENR or other, and even cold fusion, if scientific reviews should show the opportunity). A gap to be filled because the concept of sustainability essentially revolves around the concept of energy in a context of sober uses, avoiding waste and polluting emissions.

There seems to be a serious structural gap in the European (and specially Italian) innovation system regarding the financing of conceptual experimentation in the energy sector. This gap severely limits the capacity to make real breakthroughs towards a truly sustainable development model. Closing it would require: a review of public R&D policies; a new pact between frontier science and society; neutral and pluralistic funding mechanisms (e.g. similar to EIC Pathfinder, but focused on conceptual energy).

Isn't all this enough to think about a review of the entire regulatory framework for start-ups and patents at national and EU level? Will the funding of research and innovation by individual EU Member States, especially for basic research, strategic projects or those of high national interest, ever cease to be considered "*a sin against the free market*", a fault that creates a "*reparatory debt*" that will inevitably have to be repaid? Just when that global free market is now seriously committed to applying reciprocal tariffs & duties!

It is difficult to say how close or far from equilibrium the EU system is today and presumably, given possible reconfigurations due to the instability generally perceived in current times, a long-term extrapolation, given the uncertain circumstances (of a "*model society*" forced by an elusive uncertainty to rely on "*carpe diem*") may make little sense. Despite these real limitations, if the current trend were maintained, the resulting "*base case*" could be the following one represented in Table 5. However, the following warnings should be kept in mind in cases of trend extrapolation such as this one, where a scenario approach (not performed here, but for which the previous table can be a starting point) is quite necessary:

i. Empirical rules suggest that a trend analysis performed on historical data of n years, if it is linear according to best fit of the data and with determination coefficient $R^2 > 0.98$ as in this case, can provide a reliable projection for an extrapolation to a period between 1/3 and 1/2 of the duration of the original historical series, provided that the contextual conditions remain stable or almost stable.

Extrapolation on the Energy Investment in UE (in Billion €; base 2023) according to Present Trend										
	Year	Italy		UE			UEPublic	UEPrivate	$\Delta_{(Tot-Priv)}$	$\Delta_{(Pub-Priv)}$
P		Public	Private	Public	Private	Total	%	%		
R	2002	2,5	3	25,0	35,0	60,0	42%	58%	25,0	-10,0
E	2005	3	3,5	30,0	40,0	70,0	43%	57%	30,0	-10,0
S	2010	4	5	35,0	50,0	85,0	41%	59%	35,0	-15,0
E	2015	5	6	40,0	55,0	95,0	42%	58%	40,0	-15,0
N	2020	6	7	45,0	60,0	105,0	43%	57%	45,0	-15,0
T	2023	7	8	50,0	65,0	115,0	43%	57%	50,0	-15,0
F	2030			57,1	75,0	132,2	43%	57%	57,1	-17,9
U	2035			62,7	82,0	144,7	43%	57%	62,7	-19,3
T	2040	Results by extrapolation of equations (5) and (6)		68,3	88,8	157,1	43%	57%	68,3	-20,5
U	2045			73,9	95,8	169,7	44%	56%	73,9	-21,9
R	2050			79,5	102,7	182,2	44%	56%	79,5	-23,2
E	2075			107,7	137,3	244,97	44%	56%	107,7	-29,53
?	2100			135,8	171,8	307,57	44%	56%	135,76	-36,05

Table 5

ii. There is no universal theoretical rule, but there are empirical and common sense guidelines, based on:

- Duration of the historical series (n years of observation). - Context of structural stability (i.e. whether the conditions that determine the trend are stable). - Purpose of the projection (operational decision, strategic, policy scenario...).

iii. If the systemic conditions (i.e. the forces that drive the trend: market, technology, regulation, social behavior) change, the trend becomes more fragile. One can hypothesize three levels:

- 1. High Stability The underlying dynamics remain unchanged (e.g. population growth, electricity use, constant adoption of a technology). ⇒ The trend can be projected for 1/3 - 1/2 of the time series, as mentioned above.

- 2. Medium Stability Secondary variables change (public policies, regulations, costs), but the main dynamic is still valid. ⇒ The projection horizon is reduced to about ¼ of the historical duration.

- 3. Stability Low (high turbulence)

At least one structural variable (technological, geopolitical, climatic, macroeconomic) changes. ⇒ Only short-term projections (1–2 years) can have predictive value.

In a future panorama that these methodologies can roughly outline, the preponderant return of States in the research sector compared to private individuals can certainly make a difference and produce results in the energy sector. Furthermore, in political, economic, industrial, social and even ethical-religious settings, there is nothing but talk of the efficiency improvements that artificial intelligence and robotization will allow in all human production processes. But such efficiency improvements will necessarily translate into a loss of jobs, especially for professions today considered "intellectual". And where if not in research can they be used to enhance the resolution of energy problems that still afflict the world with wars that feed the instinct of power and dominance that the spirit of our time is feeding on? The alternative cannot and must not be either a return to "Luddism" or to a permanent conflict between the elites and the desperate part of a society destined for decay and chaos!

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References

[1] For instance, refer to Appl. Sci. 2024, 14(14), 6297; https://doi.org/10.3390/app14146297 - paragraph 9.Patents: patent application GB2404348.1

[2] September 2022 - Frontiers in Psychology - see DOI: 10.3389/fpsyg.2022.997062. https://www.frontiersin.org/journals/psychology/articles/10.3389/fpsyg.2022.997062/full

[3] Guidelines for the identification and use of the best available techniques pursuant to art. 3, paragraph 2 of Legislative Decree 372/99; see ATTACHMENT to the OFFICIAL GAZETTE OF THE ITALIAN REPUBLIC 12-2-2009 - General Series - no. 35.

[4] Sources Used: World Bank – Investment in Public-Private Partnerships in the Energy Sector; IEA – World Energy Investment Reports; European Commission – Energy Investment Reports; EIB – Investment Reports - Energy Policy Tracker; ScienceDirect; Investopedia. The data have been normalized in 2023 euros and interpolated where specific data are missing.