

Transfer of knowledge from science to industry in the energy sector: the case of CNR Institute ITAE

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And therefore never send to know for whom the bell tolls; It tolls for thee.
John Donne Meditation XVII

1. Introduction

The issue of environmental sustainability cuts across a wide range of scientific and popular studies. Thus, it can be approached from many points of view, each suitable to shape an idea that in some ways, is already part of the cultural heritage of our century. The need to reconcile economic growth and fair distribution of resources in a new development model began to emerge in the '70s (J. Kovel 2007)¹ due to the effects of the oil crisis. The increase in oil prices led to rising energy costs and a consequent inflation that shook the world economy; at the same time, however, it also triggered an awareness connected to the belief that the concept of traditional development, linked as it was only to economic growth, would cause the collapse of natural systems in the near future. Rooted beliefs in economic and social progress began to lose strength and a new vision started to spread relying on the use of renewable energies as a solution to the scarcity of fossil fuels and, in particular, of oil. The belief involved broad categories of thought and formed the foundations of a new vision regarding the limits of our planet and of a new way of dealing with these limits. A new consciousness was beginning to develop; it drew the attention of citizens to social and ethical issues especially in relation to environmental degradation, pollution, distribution of wealth, the depletion of

¹ Joel Kovel, *The Enemy of Nature: The End of Capitalism or the End of the World?*, Second Edition, 2007.

energy resources, human rights, justice and social equality. In other words, the concept according to which economic growth itself is not enough was being formed: development is real only if it improves the quality of life in a sustainable way.

Today, we are more aware and are experiencing a new meaning of social living, which previous generations never contemplated: a modern meaning to being a "citizen" which manifests itself not only through political preferences or voluntary actions, but which is inherent in the choices of relevance on what to buy and consume. "We are starting to put our money where our ideals are" (R. Stengel, 2009).

Our social structure with its norms and values is veering toward guidelines aimed at reconciling economic behaviour with ethical values. Based on the above considerations, the question is not only what is good for man but, rather, what is good for the development of the system. Thus, development, which emphasizes the relationship between the protection and enhancement of natural resources with an economic, social and institutional framework, is aimed at satisfying the needs of the present without compromising the future, as stated by the so-called Triple Bottom Line². According to this concept, a socially responsible organization, besides assessing its strategy with respect to economic and financial parameters, must also integrate the economic aspect with an assessment of environmental and social behavior, considering the "Three Ps": Profit, People³, Planet.

The issues under discussion concern the well-known phrase "environmental sustainability" which includes not only issues on environmental degradation but also ethics, economics, and the most advanced technology and scientific research, bringing together experience of study and increasingly turbulent activities, contemplating cross

² The triple bottom line concept of sustainable development attempts to integrate not only environmental and social aspects but also economic aspects. It brings together three critical elements: environmental responsibility, social equity and economic performance. For further reading on the triple bottom line concept and related reporting issues see AA. VV., *I Processi Di Standardizzazione in Azienda. Aspetti Istituzionali, Organizzativi, Manageriali, Finanziari, Contabili*. Atti del X Convegno Nazionale di AIDEA Giovani –Dipartimento degli Studi Aziendali Università degli Studi di Napoli Parthenope 17-18 marzo, 2005. Franco Angeli, Milano. P. Ricci (a cura di), *La responsabilità sociale dell'impresa: Il ruolo e il valore della comunicazione*, 2004, F. Angeli, Milano

³ Vecchiato G. *“Relazioni Pubbliche: l'etica e le nuove aree professionali”*, Franco Angeli, Milano, 2006, (p. 131).

cutting issues such as the violation of human dignity and human freedom, poverty, economic decline and the recognition of rights and equal opportunities.

This work is part of a wide group of studies on environmental sustainability, with specific reference to energy as one of the main strategic priorities in the current phase of history. Insights on technologies regarding the energy chain are part of the great changes in the field of production, distribution and use of energy. The energy sector, driven by the need to reduce environmental impact, to increase efficient use of resources and to diversify primary sources, looks for new high performance technologies, to minimize emissions, and exploit renewable energy sources⁴.

In this perspective, a model of virtuous public research experience, which belongs to our territory, is presented here in order to highlight beneficial aspects regarding the transfer of knowledge from science to industry.

The Institute of Advanced Technologies for Energy “Nicola Giordano” (ITAE) of Messina is a research institute of the National Council of Research (CNR). Since its foundation, in parallel with the evolution of the concept of sustainability, ITAE has been a reference point and centre for promotion and dissemination of scientific knowledge in close relation to environmental sustainability issues, with also the design and implementation of new energy technologies of wide economic and social interest.

There are three main reasons to present CNR-ITAE here. The first concerns a belief in the great potential impact of industry on the environment, and the consequent need to imagine a new kind of relationship between industry and environment. In the short-term, sustainability must be the target of reference more than ever in a close

⁴ “The impact of public science on economic growth has been discussed among economic scholars, professionals and policy makers since decades. There are various contributions of public science including the enhancement of the knowledge stock and problem solving capacities in the economy, the education of skilled graduates, the creation of new scientific methods and instruments, and new firm formation (Salter and Martin 2001; Foray and Lissoni 2010). While the empirical literature clearly establishes a positive relationship between investment in public science and (long-term) economic returns for a variety of dimensions, such as corporate patenting (Jaffe 1989), productivity growth (Adams 1990), new product and process development in firms (Mansfield 1991, 1998; Cohen et al. 2002; Toole 2007) and even the emergence of entirely new industries (Zucker and Darby 1996, Zucker et al. 1998) this evidence is largely based on the United States and still emerging in Europe (Geuna and Nesta 2006)”. Dirk Czarnitzki • Katrin Hussinger • Cedric Schneider The nexus between science and industry: evidence from faculty inventions *J Technol Transf* (2012) 37, pp. 755–776.

relationship between the evolution of research and growth of industry. The second reason, in some ways parallel to the first, is the virtuous path that ITAE Messina is still following in the field of sustainability, not only on issues of scientific research but also in relation to the business world with which it has an ongoing relationship. The third reason concerns the opportunity to highlight that this public institution is quite interesting considering its relationship with the territory it works in, and where there is often a lack of sensibility for environmental issues.

The paper is organized in three parts. First, the position recently expressed by Confindustria and the content of Horizon 2020 in terms of sustainability are pointed out as references for development in the near future.

In the second and third parts, the CNR-ITAE Institute is presented, showing how the aims of its research, scope and methodological choices have always adhered to the guidelines of Confindustria and Horizon 2020, as examples for the industrial world of virtuous behaviour regarding environmental issues.

2. Two examples of behaviours aimed at increasing environmental protection: the position of Confindustria and the objectives of Horizon 2020

The theme of environmental protection has been creating increasingly widespread interest, in recent times. Its transversality, made strong by the virtuous, shareable content, has led to an increase in the number of initiatives finalized at promoting behaviors aimed at environmental protection. In this paper, two models are specifically referred to as they are considered representative of concrete actions targeting behavior inspired by environmental protection. The first example in Italy concerns the position taken by Confindustria. The second example is located in a broader European context, Horizon 2020.

Confindustria has recently published a handbook which contains the reference values by which companies should be guided by virtuous behavior in the area of environmental sustainability: *The Confederal Charter of Principles for Environmental Sustainability*. This document has an important role not only because it indicates the

reference points which may constitute a behavioral platform for companies that want to adapt their actions so as to be environmentally friendly, but also because a decided determination to give the economic and industrial world a strong signal underlies its preparation, pointing toward a new path characterized by behavioral and ethical content.

The Charter, therefore, is an indicator of behaviors inspired not only to create wealth but also the wellbeing of the community as a true corporate culture. In this perspective, environmental sustainability becomes a pillar of development and should be pursued through a synergy between the industrial system, institutional and social partners. Companies and organizations of associated enterprises that voluntarily adhere to the Charter containing the Principles for Environmental Sustainability assume the values and commitments contained therein as an integral part of their work and their process of production growth.

In brief, the 10 commitments in the Charter are as follows:

Achieving environmental sustainability goals in the short, medium and long term;

Adoption of a precautionary approach;

Efficient use of natural resources;

Control and reduction of environmental impact;

Centrality of innovative technologies;

Product stewardship;

Responsible management of the supply chain;

Awareness and training;

Transparency in relations with the parties concerned;

Consistency in international activities.

Action at the level of the European Community by Horizon 2020 is different. In this second decade of the 21st century, Europe will have to face the new challenges posed by recent changes in the world order. Innovation, increased productivity, and guarantees of long-term growth respecting the environment will be the key factors that will help Europe move intelligently and effectively to deal with changes. Horizon 2020

is a document of strategic planning designed to meet these new demands, which will implement innovation, research and technological development.

Activities will start on 1 January 2014 and will be valid for seven years from 2014 to 2020 with a total budget of around € 80 billion. The main strategic objectives of Horizon 2020 are organized in the following projects (see tab.1):

Tab.1 The main strategic objectives of Horizon 2020

Project	Amounts	Purposes
Science of excellence	28 billion	This priority will raise the level of excellence in Europe's science base and ensure a steady production of world-class research to ensure competitiveness in the long term
Industrial leadership	20 billion	This priority aims to make Europe a more attractive place to invest in research and innovation, promoting structured activities by companies
Societal challenges	36 billion	This funding will focus on the following issues: Health, demographic change and well-being; Food security, sustainable agriculture, marine and maritime research and the bio-economy; Energy sources, clean and efficient; Intelligent transport, green and integrated; Climate action, efficiency in terms of resources and raw materials; Inclusive, innovative and secure societies

Source: own elaboration

The program will also cover human and social sciences, which are essential to guide the public on issues concerning climate change and sustainability in general. It is important to emphasize that sustainable development is a general objective of Horizon 2020. The specific funding for climate action and efficiency in terms of resources will be supplemented by other specific objectives of Horizon 2020, so that at least 60% of the total budget of Horizon 2020 is connected to sustainable development. A large part of this expenditure will contribute to strengthening mutual climatic and environmental objectives.

3. CNR-ITAE

In the previous paragraph, two realities have been presented, and they express, even if in different ways, a common approach to one of most important concepts that characterizes our century: the model of environmental sustainability. In this sense, globalization has created a network connection between multiple heterogeneous elements that all contribute to determine events. The case concerning the ITAE Research Institute of the CNR, is an integral part of that network connection. Knowledge transfer from science to industry has been shown to be beneficial for industry. In this respect, among the various contributions of public science, the increase in knowledge stock in the field of environmental problems has had a positive effect on economic growth (Foray and Lissoni 2010). Below we present the CNR Research Institute as an emblematic example of support to environmental sustainability for industry, highlighting the implied connections in relation to the paths that Confindustria and Horizon 2020 indicate.

The background

The Institute of Advanced Technologies for Energy (ITAE) "Nicola Giordano" was founded in Messina by the National Research Council (CNR) in 1980, by Prof. Nicola Giordano under the name of "Institute for Research on Methods and Chemical Processes for Energy Conversion and Storage". Prof. Giordano was the director until his death in 1996, setting out the strategy and aims of research that are still relevant⁵.

Recently, a "*Center for the promotion of innovation and the transfer of energy technologies*" has been built in an area adjacent to its headquarters. The laboratories have been prepared for research closer to the direct interests of companies that have the

⁵ At the beginning of its activities, the Institute was located in an old factory of essential oils, within which research laboratories were adapted. Later, the growing importance in this field of expertise and the significant strategic role shown in the development of energy technologies led to a grant from the Government with which it was possible to build a new and much larger building, suitable to the growing needs of a research institution. The new building, located in front of the old factory of essential oils, has been fully operational since 1993. It consists of 19 fully equipped laboratories for the preparation and characterization of materials and components, the construction and testing of devices and prototypes. These laboratories are located in a building that is spread over three floors with a total area of 4800 square meters, and also includes, offices, a conference room, library, guest lodgings and canteen.

potential to place an office inside the building, forming what is called a public-private laboratory. This allows companies and the public research institution to strengthen the final part of a process leading to innovation, bringing new innovative technologies to the market. The structure is capable of organizing and promoting the relationship between potential users and producers of new energy technologies close to being marketed, in order to strengthen scientific and experimental collaboration directly with the business world.

The ITAE mission

The original idea of the Institute, prefigured by Prof. Giordano since 1980, was based on the belief that hydrogen would be one of the main elements of the energy supply of the future. He glimpsed the huge potential of this and undertook research on hydrogen production and storage for its use in the field of mobility, and as a clean energy carrier coupled with the use of new efficient technologies for its transformation with low environmental impact. Prof. Giordano's entrepreneurial background rendered him capable of transmitting his driving, contagious enthusiasm, anxious to create a cultural environment in which everyone could better express their full potential in research, looking at long term sustainability and thus, of worldwide interest.

Later, the research topics were updated to the scientific development of the sector and the increasing demands of the market, while still remaining in the field of transformation and storage of energy. At heart, the identity, ideas, values and attitudes that are evident in all the Institute's activities are now oriented towards a logic of environmental protection that is expressed in the general objective of reducing CO₂ emissions.

The identity of ITAE, which has consolidated over time, is organized in different levels which correspond to issues involving all research activity, and also specific areas of administration and finance. Without going into detail on the structured, national bureaucratic organization headed by CNR, which is also an important element of consideration in the mission of the Institute, the research activities of ITAE focus on new, environmentally sound energy technologies with particular attention being paid to the development of different types of fuel cells. In-depth know-how acquired means that

ITAE can start from the preparation of individual components of a cell to the realization of power stacks.

Attention is also paid to the development of electrochemical energy storage systems with super capacitors and batteries. At the same time, issues related to the production and storage of hydrogen, foreseen by ITAE already in 1980 as the energy carrier of the future, continue to be a strong element in the strategy for market penetration of electric vehicles fed by hydrogen. A current study is investigating the many possibilities of producing alternative fuels for cars, and the use of industrial organic waste to produce hydrogen and/or biofuels.

Solar energy is also studied. Following the deep-rooted will to significantly reduce the use of fossil sources, one line of research is directed to photovoltaic cells, to systems of photo decomposition of water, and to thermal systems in general. With regard to thermal research, innovative adsorption systems for space cooling using thermal sources available, both from solar and/or waste heat, are being developed.

A common methodology for all research performed at ITAE consists of the study of procedures for materials synthesis and characterization, the development of components and the design and construction of prototypes, testing application in embedded systems or mobile and field demonstrations, along with high efficiency and low environmental impact.

In summary, research can be grouped into four broad themes:

Fuel Cells

Hydrogen and environmentally friendly fuels

Storage and rational use of energy

Integration of new technologies with renewable energy.

Each study is organized into multidisciplinary fields of technology, with specific objectives and development strategies that take interactions between different sectors for the development of combined systems into account. The purpose is reduction of energy consumption, efficient use of resources and environmental compatibility. In addition to the four lines of research, the strategic plan includes three other support activities. The first two, "legal" and "socio-economic", deal with matters relating to

specific lines of research or parts thereof. The third support line cuts across all others, and concerns "consulting and technology transfer".

Another area of particular interest is the training that is conducted at ITAE. In following a high-quality research-oriented approach, scientific productivity becomes an internalized value, open to issues of sustainability. This vision is reflected in the basic training of young researchers trained in an international context in which they spread scientific knowledge with a high output of articles and patents. Based on the foregoing reasoning, there is no doubt that all that ITAE puts at the disposal of the industrial world in the progressive advancement of environmental sustainability clearly overlaps with the values laid down in the Charter of Confindustria, as previously mentioned.

In a different way, common ground with the Horizon 2020 program is analyzed. In this case, it is necessary to shift observation of the Institute to a more technical field, with which it is more directly involved. One of the priorities of Horizon 2020, "societal challenges", includes the following, which are also the subject of specific research by ITAE:

1. Secure, clean and efficient energy
2. Smart, green and integrated transport

With regard to the former, four broad lines of actions are foreseen:

- a) Reduction of energy consumption and carbon footprint through smart and sustainable usage
- b) Low cost, low carbon electricity supply
- c) Promotion of alternative fuels and mobile energy sources
- d) Realization of a single European electricity grid

Research currently being developed at ITAE converges in the same line of action, indeed, they more specifically concern:

- developing the use of renewable energy sources such as solar photovoltaic, solar thermal, microeolic, geothermal etc.;
- the development of fuel cells, electrolyzes, technologies for hydrogen production, electric and thermal energy storage systems;

- the study of the integration of various technologies for the production of electrical energy at low environmental impact, for the realization of a smart grid.

With regard to the latter, research activity on fuel cells, which has been ongoing at ITAE for some time, is also aimed at the realization of sustainable mobility for both the automotive and naval sectors.

The degree of development achieved by the public structure in the present study is evident from what has been observed and reported above. A further interesting observation can be given regarding parameters that can provide a measure of the degree of results up to now obtained by ITAE.

Indications of results

The observations hitherto proposed have shown that ITAE has achieved important results in terms of research and development in new energy technologies. The results obtained address two questions that relate to today's energy perspective at both a national and international level. Indeed the key points characterizing today's energy strategy interest are:

- use of energy resources related to the territory and, if possible, renewable;
- intervention on the users system to optimize structures to make the best use of energy, thereby lowering resource utilization;

Regarding the first point, ITAE has developed a high level of know-how on materials, components and processes suitable to produce prototypes. Representative examples include systems with low environmental impact for electrochemical conversion of energy from fuels (hydrogen, methane) to electrical energy, or electric storage batteries (advanced batteries, supercapacitors), often in collaboration with Italian and foreign companies.

The second point is inherent, to a greater extent, to theoretical and informative scientific issues with an impact on the social system, and results may be identified in the following areas

- Number of scientific publications;
- Increased staff numbers.

- Obtaining funds from EU or regional programs, or through direct relationships with businesses.
- Collaboration with the academic world.

The following table (Table 2) shows the results of ITAE's scientific production from 1998 to 2011. In this regard it should be noted that, given the characteristics of the type of research carried out mainly on commission and for this reason often bound by confidentiality agreements with business customers, from the data presented, the prevalence of technical reports for activities of commissioned research, compared to scientific articles in journals or conference proceedings is clear. Indeed some of the technical reports were later processed for the purposes of publication in journals or conference proceedings, others, bound by confidentiality relationships with client companies, were classified as technical reports for research on commission.

Tab.2 ITAE research products

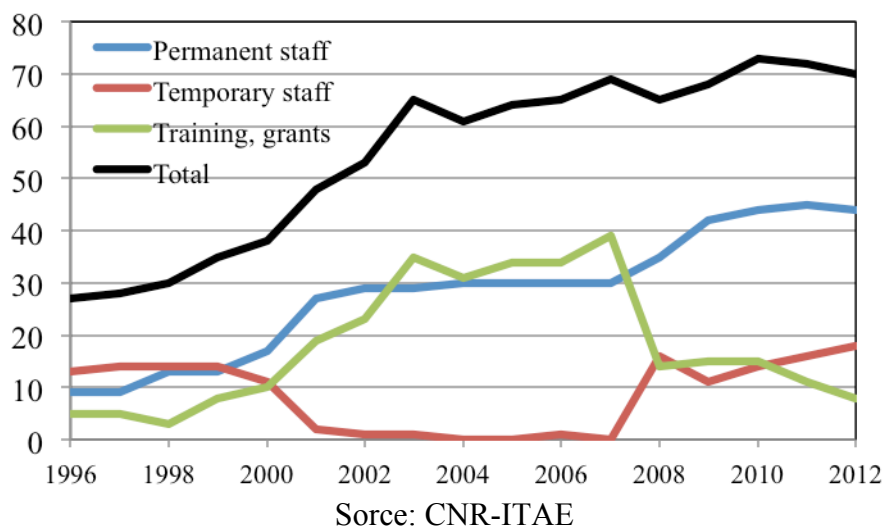
Years	Patents	Papers in international journals ISI	Articles in refereed conference proceedings	Monographs	Technical reports of commissioned research	Abstract Proceed.
1998	0	34	30	0	17	10
1999	1	21	32	0	9	12
2000	0	25	21	0	12	8
2001	0	32	23	0	15	6
2002	2	19	25	0	21	8
2003	0	15	25	1	37	12
2004	4	29	33	0	40	16
2005	1	25	35	1	30	16
2006	3	33	32	0	36	21
2007	2	32	29	1	50	46
2008	0	39	13	1	55	26
2009	0	39	30	2	51	24
2010	0	34	24	4	48	39
2011	0	33	26	2	39	18

Sorce: CNR-ITAE

Regarding the increase of staff (Fig. 1), a progressive increase over time can be observed. However some features should be pointed out. Indeed, given the trend of

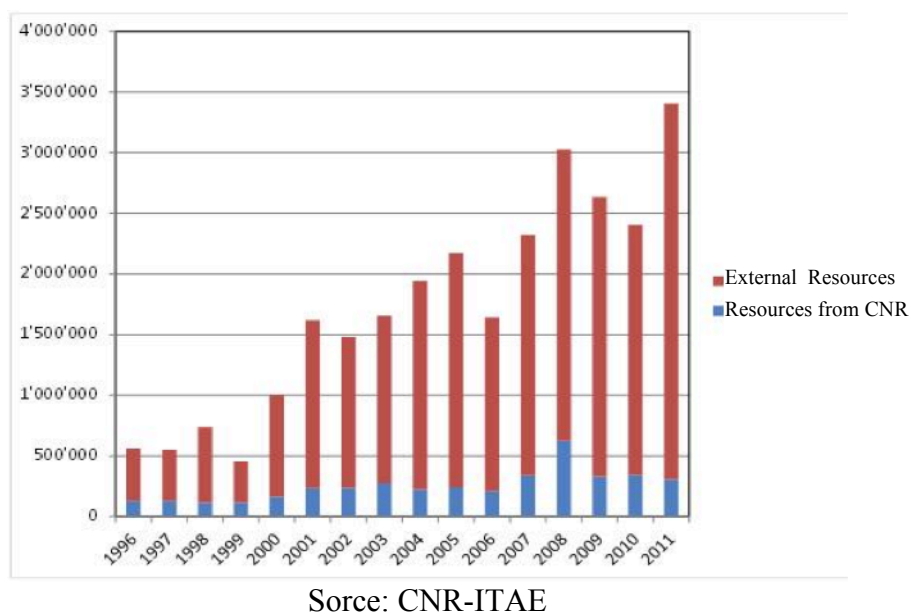
temporary staff (blue line), it can be seen that over the period 2001 - 2007, the curve is nearly at 0. During the same period, there was an absorption of such personnel into the permanent staff, as can be seen from the graph (red line).

Fig 1. Personnel over time at CNR-ITAE



Furthermore there was a significant number of training personnel (green line) which, after a period of steady increase, abruptly decreased (2008) as result of a transition of young people from training to the role of researcher in temporary staff.

Fig. 2 Funds for research



Considering the trend over time of funds for research obtained by ITAE (Fig. 2), about 85 - 90% came from sources outside CNR as the result of participation in European and national calls for proposals, or for research commissioned by companies. As already mentioned, given that research funds were obtained on a competitive basis, the topics covered, and skills acquired, constitute an offer of research that meets the requirements of quality and innovation required by the various calls for proposals and suited to providing results of particular interest to companies that carry out their activity in the energy sector.

ITAE also carries out important exchanges with the academic world. In particular, with the Faculties of Engineering of Messina and Catania. Many students have prepared their final degree theses at the Institute. In addition, this ongoing collaboration has led to the realization of Master and PhD courses related to ITAE's topics of research. These relationships therefore consolidate a synergy among research institutes, universities, industry and government that appears to corroborate the concept of *Triple Helix* which develops the theory that these partnerships allow the creation of infrastructure in the area of knowledge aimed at the social development⁶.

4. Conclusions

This analysis has highlighted a virtuous connecting link between the world of research and the world of industry in the energy sector. The case of the Institute CNR ITAE Nicola Giordano of Messina is presented, as a public research Institute which is an important point of reference for the research and development of new energy technologies. The article started from a comparison between issues concerning the development of behaviours aimed at environmental protection offered by Confindustria and Horizon 2020 and the activities carried by the Institute, always in line with the same issues. To better highlight this type of activity, several ITAE's aspects were observed

⁶ H. Etzkowitz "The triple helix" university-industry government, innovation in action. 2008, Routledge, New York

taking into account qualitative and quantitative perspectives appropriate to representing such a virtuous structure.

It has been seen how the energy sector is characterized by the strong impact of innovation regarding scientific, technological, social and economic spheres. This versatility is a feature that has, as its main consequence, temporal references in the medium and long term. The energy sector cannot change quickly, but even if the introduction of new technologies will be slow, it will be inevitable as it is primarily driven by the needs of the environment, depletion of oil resources and the political strategies also linked to international agreements.

In any territory, the presence of a structure for technological energy research of adequate size and with high levels of international experience is a crucial point in the knowledge, innovation and development relationship. It may represent a competitive advantage for companies that can exploit this opportunity, together with proper incentives, and become competitive in the new energy scenarios offering technological innovation and savings.

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The performance measurement system: the experience of Sicilian municipalities

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1. Introduction

The reform of public administration, and specifically that of Local Authorities, has meant that the most economically advanced countries have been affected by a modernization processes aimed at the introduction of New Public Management approaches and principles (Hood,1991; Pollitt, 1990; Borgonovi, 1988; etc.).

Since the 1990s, a particularly interesting element in this process of change has been the introduction of an internal control system in the Italian Public Administration. Indeed, it has moved the attention of decision makers away from compliance with formal procedures toward efficient resource allocation and, therefore, toward achieving objectives in from a multi-dimensional viewpoint. The underlying assumption is that measures of a quantitative nature, focused on cost, provide little information on long-term performance. For these reasons, this paper focuses on the planning and strategic control system in Sicilian local authorities. In detail the aim of the paper is to check whether the Balanced Scorecard is implemented in local authorities, or if there are at least the beginnings of implementation of the same. In order to verify the propensity of these organizations toward multidimensional performance measurement, a quantitative research methodology was used, based on analysis of data obtained from a multiple choice and open answer questionnaire.