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Research and development evolving trends and practices : towards human, institutional and economic sectors growth

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Chapter 1

Introductory Chapter: R&D Trends and Evolution - Emerging Concepts, Frameworks, Policies, Management Systems, and Applications

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Additional information is available at the end of the chapter

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1. R&D trends and evolution

1.1. New trends in global funding

The changing economic conditions and balance of power around the globe have changed how nations and agencies prioritize investment in research, development, and innovation. Moreover, the growth of scientific research during the past decades has outpaced the public resources available to fund it. This has led to a problem for funding agencies and politicians and pushed toward science with expected benefits for society. For instance, Horizon 2020, the biggest multinational research program in the world, launched by the European Union (EU), shifted toward funding research and innovation activities that are ***"closer to the market."*** International cooperation is gaining a high priority on the funding agenda of nations and agencies for maintaining global competitive advantages, tackling global societal challenge, and supporting external policies [1–4].

1.2. New research evaluation frameworks

Responding to changing landscape in local, regional, and global funding needs and directions, new research evaluation frameworks were introduced stressing the importance of social impact of research besides traditional measures of research including metrics (Data Citation Index, Altmetric, Citation Score, etc.). Examples of new research evaluation framework include Research Excellence Framework (REF) in the UK, STAR METRICS in the USA, National Institute for Academic Degrees and University Evaluation NIAD in Japan, Excellence in Research for Australia (ERA), Canadian Academy of Health Science (CAHS), Evaluation Agency for Research and Higher Education (AERES) in France [5–16].

There is also a growing issue around standardization, development of new frameworks and the potential of data mining and social media in creating a paradigm shift in the way research is evaluated.

1.3. Research classification and science diplomacy

Consequently, research is classified in various categories: institutional research, basic research, applied research, research and experimental development, social innovation, and technological innovation [17–23].

"Science diplomacy" in the international cooperation in the research and innovation is an instrument of soft power and a mechanism for improving relations with key countries and regions.

1.4. New policies, strategies, and ecosystems

Realizing the importance of research, development, and innovation in driving growth and addressing societal challenges, institutions, nations, and regions are developing new policies, strategies, and ecosystems to promote R&D and innovation. There is no unified practice in devising policies, adopting strategies, and developing ecosystems for R&D and innovation. We are rather confronted with scattered efforts around the globe lacking homogeneous, synchronized, and standard actions [24–35].

1.5. New concepts emerging

Open innovation is a new concept introduced to drive R&D and innovation and to consolidate data in the hand of various economic stakeholders in order to create the so called "knowledge economy" [36–38].

Various economic stakeholders (industry, academia, government) are developing open innovation approaches, combining in-house and external resources, and maximizing economic value from intellectual property.

1.6. R&D outcome and impact

It is hard to assess R&D impact and to identify all areas that may be impacted (impact zones). It is also a challenging task to accurately estimate the timeframe to achieve an expected impact. For instance, the largest EU investment in GRID infrastructure has never delivered the expected impact within the predicted timeframe. Impact assessment is a big task and we have a long way ahead to learn from case studies, best practices, and experiences [39–42].

Moreover, identifying R&D outcome and devising outcome measurement approaches is a nontrivial task that requires a broad vision of various considerations that can shape outcome.

1.7. Rising importance of research data management and systems

To cope with a changing R&D landscape, novel data management models and systems have to be developed. Various research data management plans have been suggested and in some instance imposed by funding agencies to maximize benefit from return on investment in R&D [43–47].

Again, there is no unified practice or standard to develop a data management plan for R&D. So far various issues considered include types of data, metadata and standards, policies for data access and sharing, data storage and preservation of access, interoperability, visualization, data management life cycle, datasets collected, processed and generated by a research project, open access of data, and criteria for open access [43–47].

1.8. Emerging R&D techniques

R&D impact and outcome evaluation is increasingly shaped by emerging technologies such as visualization (dashboards), data mining, big data analytics, communication technologies building ecosystems, and R&D and innovation e-infrastructures.

2. A quick tour of book chapters

The book chapters are classified into three sections: (1) R&D for human growth and prosperity; (2) R&D for institutional growth; and (3) R&D for economic sectors. Below is a quick tour of the book chapters.

2.1. R&D for human growth and prosperity

This section covers a topical theme on human development and research-development-extension relationships. Human capital is the most important strategic factor for development. It argues that in today's world, it becomes increasingly important to know how information can be accessed, how it is adopted, and how it can be assimilated. In this respect, each country allocates budget for training, education, and extension according to its own conditions. This budget may be intended for rural community-based social assistance, but the economic and welfare effect is essential. In this way, it is aimed to increase the living standards of the families living in the rural areas. This will naturally contribute to national income and to the prosperity of society. Moreover, the development of human resources should be emphasized and a suitable atmosphere should be prepared for its widespread prosperity.

2.2. R&D for institutional growth

This section covers a topical theme on R&D for institutional growth, with particular focus on small and medium size enterprises (SMEs). The chapter in this section addresses the topic of SMEs development through public and private partnerships and the key role of research transfer and patent information analysis. The chapter argues that innovation is today one of the best ways to improve competitiveness and to create jobs. Hence, the transformation of knowledge and competencies developed in academics laboratories and research centers must be transformed in products and services. To achieve this goal, the use of patent information is one of the best ways to understand the areas concerned by the research, to find partners and often to shift academics subjects to more relevant domains. This chapter focuses on the patent information retrieval and automatic analysis (automatic patent analysis (APA)). It shows how the results are useful for the research valorization and transfer especially to SMEs.

2.3. R&D for economic sectors growth

This section focuses on R&D in three sectors of paramount importance for economic growth: smart microgrids, energy consumption and greenhouse gas emission, and metallurgical industry.

The chapter on smart microgrids addresses the important R&D issue of optimizing local resources toward increased efficiency and a more sustainable growth. The chapter argues that with the increasing number of small renewable power generation units, the addition of the grid storage and a high number of electric cars as additional loads the electrical power grid will become more complex. On the other hand, local generation units and smart control interfaces to devices call for forming smart microgrids that reduce complexity by performing local optimization of power production, consumption, and storage. We do not envision these smart microgrids to be island solutions but rather to be integrated into a larger network of microgrids that form the future energy grid. Operating and controlling a smart microgrid involves optimization for using generated energy locally, for example, from a photovoltaic system, and therefore employing demand response mechanisms as well as predicting consumption accurately. Further goals are providing feedback to the user in order to the human in the loop of deciding when and how to use energy-consuming devices. The chapter shows how these issues can be addressed starting with measuring and modeling energy consumption patterns by collecting an energy consumption data set at device level. The open dataset allows to extract typical usage patterns and subsequently to model test scenarios for energy management algorithms.

The chapter on energy consumption and greenhouse gas emission focuses on hybrid energy evaluation and greenhouse gas mitigation methods for sustaining the growth and economy of nations. The chapter argues that various evaluation methods have been adopted by researchers, academia, and ministries. The most effective method is the hybrid evaluation method. This takes into consideration strength of a particular method to overcome the weakness of another method. The chapter focuses on a recently proven integrated method on energy and greenhouse gas studies—integrated IDA-ANN-DEA (Index Decomposition Analysis-Artificial Neural Network-Data Envelopment Analysis). Case studies are exemplified using this approach in evaluating possible energy potential that could be saved in the manufacturing industries in Canada and South Africa as well as a particular food and beverage industries.

The third chapter sheds light on the transforming landscape of research and development in the metallurgical industry of Romania. The chapter traces the evolution/involution of metallurgical industry in Romania during the period 1990–2016. The chapter argues that the importance of metallurgical industry, for any state is substantial. The chapter presents a description of the main metallurgical companies in Romania, describes critical components concerning the involution of steel industry in Romania, and foresees the future prospect of metallurgical industry in Romania.

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Human Development and Research-Development-Extension Relationships

Orhan Özçatalbaş

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Abstract

Human capital is the most important strategic factor for development; as new technologies emerge, the market demand for better and healthier products and consumer demand in terms of quality and delivery time are changing. In today's world, it becomes increasingly important to know how information can be accessed, how it is adopted, and how it can be assimilated. In this respect, each country allocates budget for training, education, and extension according to its own conditions. This budget may be intended for rural community-based social assistance, but the economic and welfare effect is essential. In this way, it is aimed to increase the living standards of the families living in the rural areas. This will naturally contribute to national income and to the prosperity of society. The subject has been discussed generally in the world, especially in the case of Turkey. According to this, all over the world, particularly in developing countries, research and extension (R&E) is very important and should be considered at least as much as research and development (R&D). However, it will be ensured that societies meet with the technology produced. For this, the development of human resources should be emphasized and a suitable atmosphere should be prepared for this widespread prosperity.

Keywords: human development, technology, agriculture, research and extension, research and development

1. Introduction

Today, as in yesterday, in the world not all societies benefit from the available resources at the same rate. The population and problems of the world are increasing in the distribution of resources. The population of the world, which was 2.5 billion in 1950, now exceeds 7 billion and in 2050, it is estimated to be 9 billion. In areas, such as education and health, global solutions are being tried to be produced under the roof of the United Nations (UN). In year 2015, member countries adopted a set of goals to end poverty, protect the planet, and ensure prosperity for all the new sustainable development agenda. According to the UN, new agenda has 17 sustainable development goals for sustainable development which cannot be realized without peace and security. Peace and security will be at risk without sustainable development [1]. There are currently around 750 million people worldwide who are illiterate. Underdevelopment is a tremendous problem, especially among low-developed and developing countries, under the influence of uneducated and old technology. This is more evident in the rural areas and in the agricultural sector.

From the most primitive to the most advanced, every society is in a constant social change. The direction of change is forward, and it is essential to establish a flawless society system. Social change from socioeconomic perspective is to move society from the current situation of production stage to a higher stage. Very rapid social change is causing crises. However, the slow pace of change also reveals some important social and economic problems [2]. As it is known, increasing population and production are the basic dynamics of social change. These dynamics change with the effect. Increasing production is possible only through the technological applications. The new technologies developed in the rural and urban area, the field of application is quite flourishing, the momentum of social change. However, every society changes under the influence of socioeconomic factors. This shows that each society is at certain stages of development due to the characteristics they possess. According to a classification, some societies in the world today bear the characteristics of an agrarian society, some industrial societies, and a small part of the information society. In addition, some societies live the transition period. These societies live under different peculiar conditions, with different forms of production and different production relations. And today we are talking about the revolution in industry 4.0 and the features of this period. These developments affect all sectors whatever the process, there is a great need for urban and rural extension, in addition to formal education, in order to regulate production and consumption relations, especially in the transitional societies.

2. Education and extension for development

Studies on education compliance with changing conditions or human resources and factors affecting country's development were started in the eighteenth century with first economist who revealed the idea of classical economics and this process was improved with work by other scientist. According to this, the first attention to the importance of investing in human skills in economic development has been the pioneers of Adam Smith and classical economics. Schultz (1961) and Denison (1962) have shown that education contributes directly to the growth of national income through the development of the capacity and capacity of the workforce. In a study, Denison (1962) found that 23% of the growth in the US production between 1930 and 1960 was due to the increase in the level of education of the workforce. In another study by Denison (1967), 15% of the economic growth was found due to an increase in the level of education. This rate is 12% in the UK, 7% in Italy, and 2% in Germany from other

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industrialized countries. Canada ranks first among the countries covered by 25%. The same approach has been applied in some other countries. The results are as follows: 23.2% in Ghana, 16% in Nigeria, 16.5% in Argentina, 6.5% in Honduras, and 3.3% in Brazil. These results in both developed and developing countries, since the 1950s, "a significant part of the growth in output can be explained by the increase in the level of training of the workforce." However, it should be noted that these estimates are based on various theoretical assumptions. In the following years, many studies were carried out. Again, there is a relationship between education and output growth. In a study by Hicks (1980), in 83 developing countries between 1960 and 1977, the relationship between literacy, life expectancy, and growth as a measure of cooperative development was examined. The findings showed that literacy rates and life expectancy in the 12 countries in which the fastest growth occurred were well above average values [3].

In 1980, in the light of findings revealed the contribution of education to human resources, and economic development was approved. Especially, the importance of education, ensuring the development of human resources in country's development, has begun to be considered as a concrete. Besides the impact of education on the economic development, significant advantages of compliance of society with new conditions have been proved.

In this context, from 1993 to now, every year studies are carried out by United Nation Development Program (UNDP) on the development of nations and presented in report form. In the report, values of human development index (HDI), health conditions of a country, education level, and human development (HD) calculated from national income allow us to make assessment on the availability of living conditions in the country. For example, according to 2015 human development report, Norway was the best country to live, whereas the Niger was the worst country to live in.

3. Human development and research and development (R&D)

Progress is evident for many measures of human development such as those for health, education, income, security, and participation and for such composite indicators as the human development index (HDI) [4]. According to this, human development (HD) is about expanding the richness of human life rather than simply the richness of the economy in which people live. HD grew out of global discussions on the links between economic growth and development [4]. In terms of showing human well-being, the HD value is an important indicator. Research and development (R&D) is very important for human potential and resource utilization efficiency. Therefore, the R&D capacity of country is important for human development (HD) of that country. The HD index provides insights into the development of countries.

There has been seen significant improvement in the HDI value for world generally and least developed countries particularly. During past 25 years, the HDI value for world increases by more than 20–40% for the least developed countries. There has been gain in HDI by every region of the world. During the past 15 years, although at slower pace, the progress in HDI has been fairly steady across all developing countries, most of the countries have moved up from previous position in human development classification [4].

Up to 2009 human development report, countries were classified in high, medium, and low development groups, whereas from 2010, it was started to classify countries in very high, high, medium, and low development groups. Norway, Australia, New Zeeland, and America were ranked at top in 2010 by human development report, whereas Zimbabwe was found at last. In 2010 report in addition to human development index, new three indexes were added, which provide new opportunities to evaluate human development from different aspects. These were expressed as the human development index modified for inequality, gender inequality index, and multidimensional poverty index [5, 6]. Norway, Australia, Switzerland, and Denmark are ranked at top in 2015 by human development report, whereas Niger is found at last. In these conditions, Norway is found to be best country in the world from living point of view. Turkey is holding 72nd position among 188 countries in the list. Despite the effort on demonstration of data aimed at ensuring the assessment on development, index values received by the countries are inadequate to explain the economic size and their place in human development. Hence, in this regard, it is impossible to find exactly something in response to some important questions.

- For example, according to facts given by OECD, Turkey is the 17th big economy of the world. Question is being 17th biggest economy of the world, what position Turkey hold in human development? According to United Nation Development Program's Human Development Assessment, Turkey is at the 72nd position. When considering the difference of 55th ranking between the evaluation result of UNDP and OECD, at first glance it may seem interesting and, there is a need for some interpretation and analysis [7].
- Still having better values of index than Turkey, located in upper ranks in terms of human development countries such as Albania, Bulgaria, Tunisia, and Jordan; again countries such as Qatar and Bahrain found in very high development group with countries found in high development group such as Kuwait, Libya, Saudi Arabia, Iran, Brazil, and Tunisia, when comparing the current political, economic, and social conditions of above-mentioned countries with Turkey's condition, Turkey's position in human development at 72nd can be very difficult to explain. Especially mentioned countries having very low standard of institutes and politics, it is necessary to consider their high natural resources and wealth effect on their presence at top. In this case, at least the effect of natural resources on economic wealth reducing the impact of all other important factors, the issues such as equitable sharing of wealth effects on index also need to be focused.

The following result can be drawn from the example given above:

1. Just moving with economic size does not reflect the development.
2. In terms of human development besides national income indicators such as education standard of living is also important.
3. In revealing the state of development of a country, only economic size (growth) is not enough; with this, importance of indicators like human development and standard of living should be taken into account in analysis.

4. Economic growth does not affect the human development at the same rate.

5. HDI parameter also does not reflect the full rank of human development of a nation.

Essentially for the reasons stated above, there should be debate on national and international levels on the concept of development. In the same contest, the method for calculating IGE, considering the different dimensions of development indicator, up to now is continued to be in the developing process.

R&D is an expensive and long-term process, and it is clear how important it is. There are a variety of indicators which show state of preference or interest a country has shown in R&D. These are shown in **Table 1** and figures as follows:

- Research and development expenditure (**Figure 1**)
- Public expenditure on education (**Figure 2**)
- Education system and functional teaching
- Per capita gross domestic product (**Figure 3**)
- Limitations of the national budget
- Awareness of the subject and culture of innovation
- The presence of qualified researchers
- Well-equipped research infrastructure
- Level of international academic relations
- Sourcing of innovation requests
- Balance between basic research and applied research
- The attitudes and beliefs of the administrators
- Attitudes and beliefs of employees
- Standard of living (**Figure 4**)
- Country and management vision
- Life expectancy (**Figure 5**)
- Human development index (**Figure 6**)

As shown in **Table 1** and **Figure 7**, R&D activities are examined by country groups during the period 2005–2012. According to this, in the high development group, R&D expenditures are highest (2.4% of GDP). Then, the high human development group (1.4%) followed by the medium (1.4%) and low groups (0.5%) are listed. It can be seen that as the level of economic development of the country increases, the share allocated to R&D is also increasing. This suggests that countries in the medium and low groups, especially those in need of redevelopment, should allocate more resources to R&D.

Human development groups	Human development index (HDI) (2014)	Research and dev. expenditure (%of GDP) (2005–2012)	Gross domestic product (GDP) (2011 ppp $ billion)	Life expectancy (2014)	Per capita (2014 ppp $ billion)	Public expenditure on education (% of GDP, 2005–2014)	Standard of living (% satisfied 2014)	Employed in agriculture (2012)	Employed in services (2012)	Labor productivity (output per worker) (ppp) (2005–2012)	Export and import (% of EDP) 2013	Internet users (2014) (% of pop.)
Very high human dev. group (49 countries)	0.896	2.4	46,814.6	80.5	41,584	5.1	73	3.3	74.3	64,041	62.5	82.5
High human dev. (55 countries)	0.744	1.4	33,466.1	75.1	13,961	4.9	71	28.8	43.8	23,766	55.6	49.8
Medium human dev. (37 countries)	0.630	0.5	13,654.0	68.6	6353	4.1	63	42.5	35.3	9483	62.3	21.9
Low human dev. (43 countries)	0.505	0	3205.5	60.6	3085	3.6	45	0	0	0	48.4	16.0
Developing countries	0.660	1.1	49,538.3	69.8	9071	4.7	63	36.9	39.1	0	59.3	31.9
Least developed countries	0.502	0	1770.8	63.3	2387	3.4	50	0	0	0	66.8	8.6
OECD*	0.880	2.5	46,521.4	80.2	37,658	5.1	72	5.1	72.3	0	57.0	78.1
World	0.711	2.0	97,521.4	71.5	14,301	5.3	64	30.3	46.0	24,280	60.4	40.5
Norway	0.944	1.7	317.5	81.6	64,992	7.4	95	2.2	77.4	92,694	67.0	96.3
Turkey	0.761	0.9	1398.3	75.3	18,677	5.4	57	23.6	50.4	41,353	57.9	51.0
Niger	0.348	0	15.8	61.4	908	4.2	50	56.9	31.1	0	64.7	2.0

Source: UNDP [4].

*Organization for economic cooperation and development.

Table 1. Selected some important indicators of human development.

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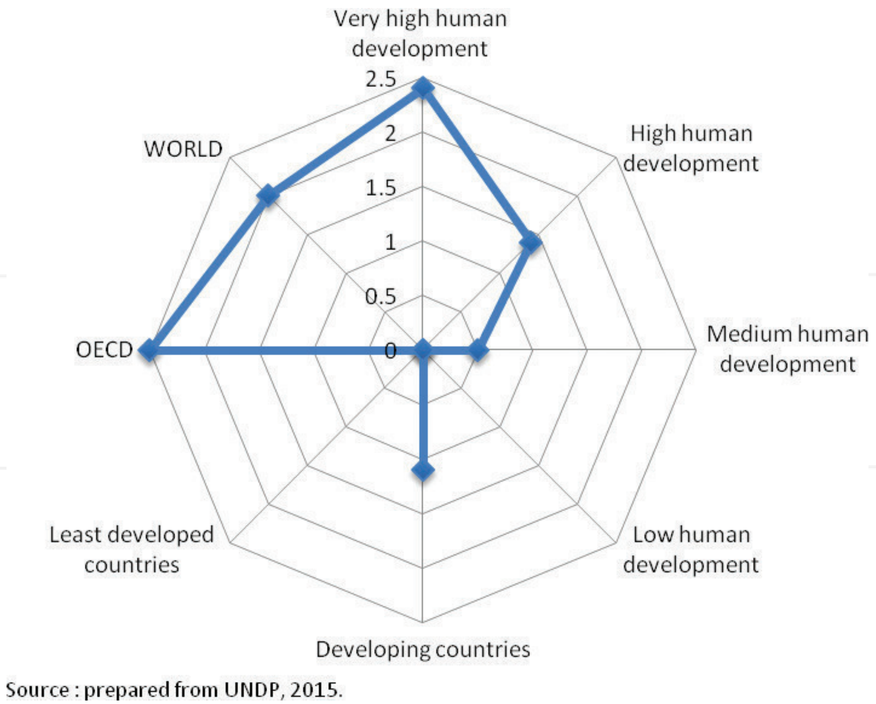

Figure 1. Research and development expenditure by country groups.

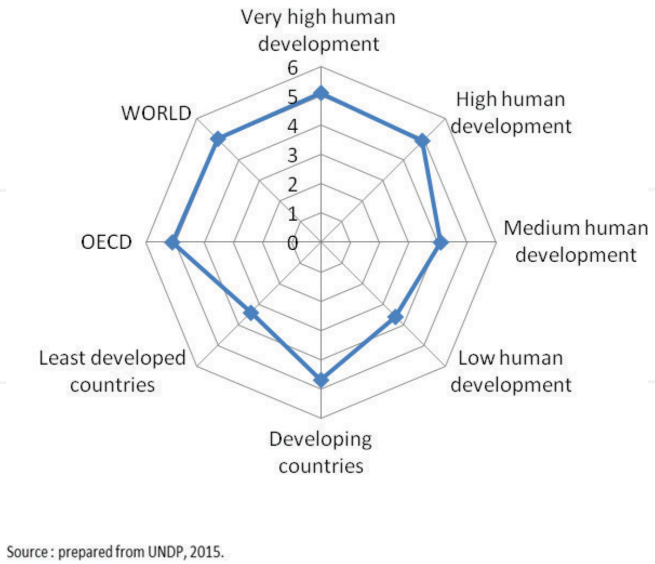

Figure 2. Public expenditure on education by country groups (% of GDP, 2005–2014).

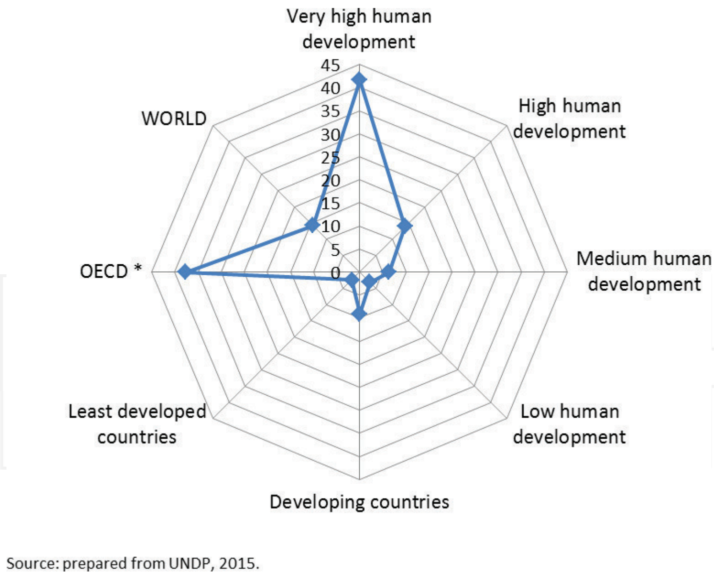

Figure 3. Per capita (GDP) by country groups (2014, PPP$).

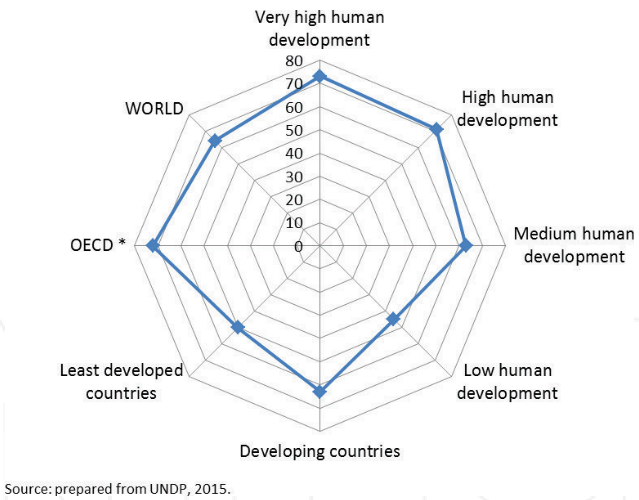

Figure 4. Standard of living by country groups (% satisfied).

The current development is measured by only quantitative data on national income, with national income the average life expectancy of population, education level, and living standard of society will be more meaningful if tried to use in the calculation method to explain development. In this respect, focusing on the development of past 40 years, living conditions in Turkey,

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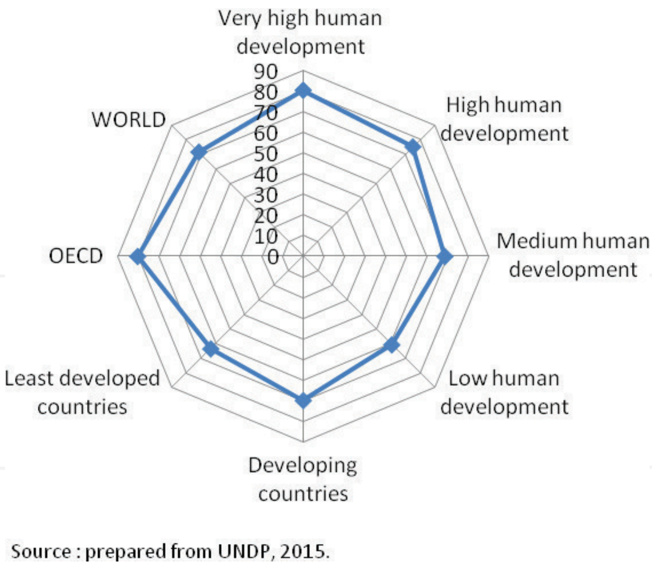

Figure 5. Life expectancy by country groups (2014).

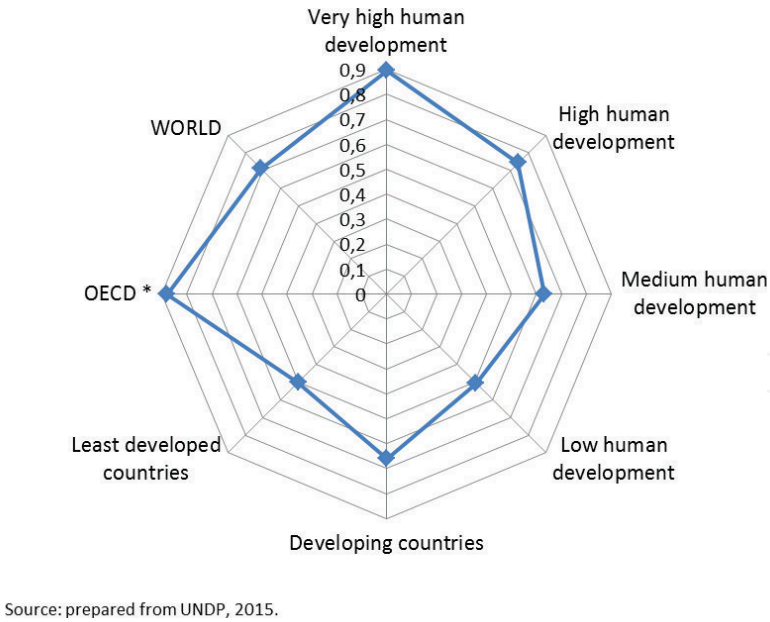

Figure 6. Human development index (HDI) by country groups (2014).

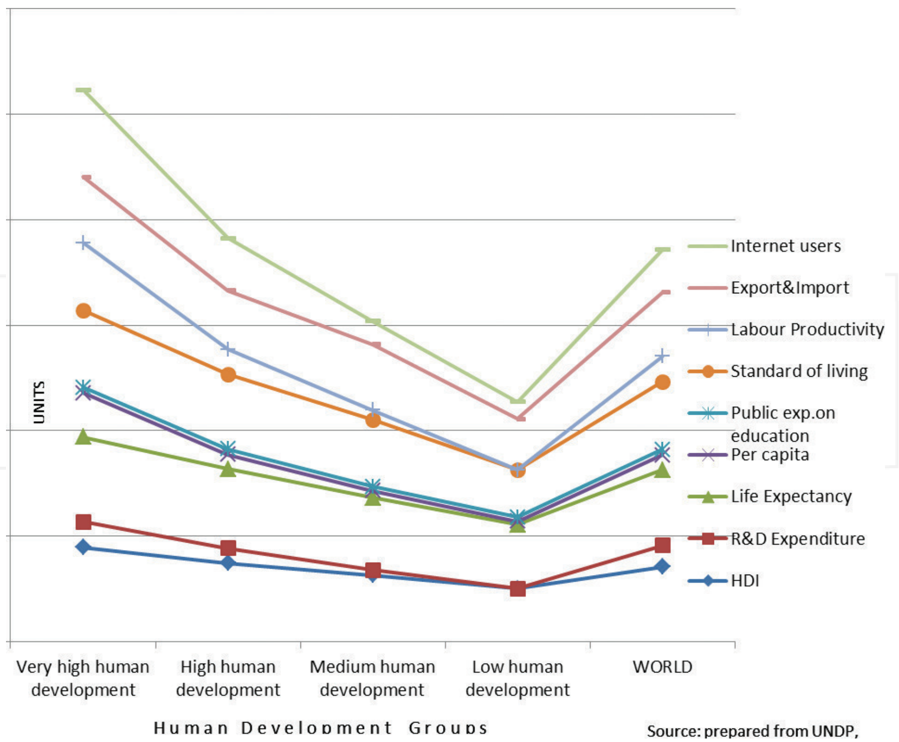

Figure 7. Selected some important indicators by country groups.

Norway, Australia, and Oman are improved by 45, 17, 21, and 1.2%, respectively, and living conditions have been exacerbated in Zimbabwe (27%). As a result, the fact that the some aspects of human development index should be discussed. As a sample, Turkey is in the high development group for human development. Position at the last rows in the group of countries shows that there are many things to be done for the some other countries.

Consequently to increase the prosperity and development of the country, everyone who cares about this has a very big responsibility. For adaptation of this task by community as a mission and in a systematic way, national education policy should be sensitive in this issue and continuity and enforcement is needed. Time is needed for this cause, but from today, anyone who is part of this community in order to contribute to this area should start "doing his job right and doing job by giving his due right." By developing our sensitivity in this direction, we can sustain this idea by contributing effort in our living and working environment.

4. A research and development (R&D) equipped with extension

The level of societal development is closely related to right planning of human resources and research and development policy. Well-equipped human resource is very important for

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research and development (R&D), and R & D has vital importance from resource development and efficient use of resources perspective. Research and development studies are essential for the future of countries. The first goal of the research must be pure science, for the future of humanity. However, the research should be aimed at changing the current situation, improving it, solving problems, and developing new technologies. The delivery of technologies developed in the second stage to the target groups should be the adoption of innovations. Countries get benefits from findings of the science in order to make their development sustainable and move ahead in this race. This is undoubtedly true for every sector. Animal and crop production can be given as an example to see concrete results. Even in terms of measurability of change, animal and crop production branches of science have important advantages. The reason behind countries with high agricultural potential cannot show the expected performance in agriculture is: inadequacies in human resource planning, lack of R&D, and failure to develop technology production capacity, along with ineffective operation of research and extension. Like in every sector, the technology that is produced cannot be delivered to target masses with the right method is big problem and need urgent importance. According to studies, in addition to R&D, R&E should also be considered important. If the findings do not arrive to target groups, sector, and stakeholders, it is not possible to get positive points from the "impact analysis" of the conducted research. For this reason, both research and development (R&D) and extension are important and should go parallel. Sufficient and adequate budget should be allocated to both.

4.1. Research and development policy

It is very clear that science and technology should be supported with long-term policy. Especially, in ensuring economic and social development, science and technology policies offer significant advantages in determining pace and direction of development.

Agriculture started to witness technological changes when the cultivators first experimented growing wild plants under different growing environment almost 10,000 years ago. For centuries, the technical performance of agriculture more or less remained the same in the great civilizations. Until middle of the nineteenth century, there were not any significant improvements in agricultural productivity. In the nineteenth century, induction of new sources of power and new machinery [8], development of scientific plant breeding led by Mendel's experiment, and development of artificial fertilizers resulted rapid increase in agriculture productivity, principally in Europe and North America.

Research and development often abbreviated to R&D covers all creative work undertaken systematically with a view to increase the sum of knowledge, including knowledge of man, culture, and the company, as well as the use of this sum of knowledge for new applications. In general, the term R&D covers three activities: basic research, applied research, and/or experimental development [9].

In 1960, Turkey switched to the planned development process. With that, the work on formulation of science and technology policies is continuing till date. During this process, Turkish science policy "Turkish Science and Technology Policy Draft (1993–2003)" has been put forward. However, although the documents contain important issues, by not fully putting in practice legal and institutional amendments made it difficult to reach expected results. Later on, work has been done to formulate a country vision on science and technology commonly accepted by all stakeholders (political institutions, public, private sector, and universities). As a result, "vision 2023: science and technology strategies project" entered implementation phase. Following activities are covered by project, assessing where Turkey stands in the field of science and technology, analysis of scientific and technological developments carried out in world with long-term objectives, acquirement of strategic technologies to achieve said targets, and formulation of policies aimed at developing or acquiring said technologies. According to decision of the supreme council of science and technology, in coordination with other related institutions and establishment, the task of implementation of the project has been assigned to the Scientific and Research Council of Turkey (TUBITAK). Turkey's R&D policies are based on TUBITAK Vision 2023. Technology fields mentioned in this document (production, biotechnology, food processing, information, protection, diagnosis and treatment, storage and packaging, analysis and measurement, mechanization, and transport) are very closely related to agriculture. Technological activities related to R&D in food and agriculture sector (development of new genotypes seed with combination of classic breeding and technology; production of seed and seedlings; characterization and preservation of genetic resources; variety of processed products and food production methods and processes; food safety and credibility; development of production system in agriculture, forest, food, and fisheries products with help of infrastructure, tools, and equipments; combating disease pandemics with protection, control, and treatment techniques and enabling integrated combating; evaluation and development of natural resources and wildlife; and development and dissemination of remote sensing, early warning system, and information technologies in agriculture and forestry) are related to animal and crops production sector. This draft aims to make Turkey an advance country depending on science and modern technology, by healthy nutrition of society, ability to meet requirement in sufficient quantity and quality, protecting biological diversity and transforming into social welfare, economically, socially, and ecological sustainable, increasing productivity, with help of agriculture and agricultural industry. The Prime Ministry National Science, Technology and Innovation Strategy document [10] makes important description to achieve above-mentioned developments. Attention is drawn toward issues that will increase the functionality of the basic dynamic in the R&D and innovation system; in this way, goal is to achieve sustainability by accelerating the speed of development in R&D and innovation capacity. Again, the development of human resources, encouraging the transformation of research results into commercial products and services, promoting multi-partner and multi-disciplinary R&D and innovation cooperation culture, encouraging SMEs to be stronger actors in the innovation system, increasing the contribution of research infrastructures to Turkey's research field (TARAL), and enabling international cooperation in the development of the science, technology, and innovation strategy, is stressed in document.

4.2. The importance of extension and research collaboration

For decades, we know that the possibilities for expansion of cropland declined steadily over the entire planet. Due to deforestation and erosion of slopes, this approach increases the risk of environmental degradation in many parts of the world. That is why the only viable options that remain are increasing yields and the change in product mix. Increasing agricultural productivity is the more urgent task than any other task, the majority of the poor in the developing world live in rural areas, and the productivity of the sector is actually in decline in many low-income countries. The use of irrigation can dramatically improve yields. The adoption of irrigation requires training of farmers and provides extension services for a long time, but it can lead to a substantial increase in yields without intervention by agricultural research. Yet in most parts of the world, the possibilities of expansion of irrigated areas are also limited and, indeed, many of those already suffering from salinization, water-logging and other issues affecting productivity. Therefore, if it is done unsuitable application to better manage irrigation and extending the yield perimeters, it is impossible to rely on it for the physical basis of agricultural production increases which the world will much need in the future. Meeting this challenge comes mainly heavy agricultural technology development and transfer systems improved, i.e., research and agricultural extension. It also depends on the education systems of farm families; some observers even argue that education is the most important factor in improving productivity.

Fulginiti and Perrin [11] have reviewed the literature on the evolution of agricultural productivity in several countries and made their own estimates using other methodological approaches. They observed that all developed countries have experienced their agricultural productivity increase, whereas most low-income countries have seen their productivity decline, even when they have widely adopted the varieties of wheat and rice from the green revolution. Based on their own analysis, they concluded that the productivity decline is real and that the adverse agricultural pricing policies can be a major cause. The overall picture is however mixed. Masters et al. [12] found improvements in cereal yields in some districts of 13 African countries recently.

Despite some positive points, we can say that the performance of agricultural productivity in developing countries have been encouraging. It is clear that agricultural technology systems of these countries face a major challenge, which is likely to further intensify in the future and which is exacerbated by the general trend of reduced funding for agricultural research observed in developing countries over the past decades.

4.3. Research and extension policy

Research and extension systems play a crucial role in all sectors, especially agricultural and rural development [13]. As is known all over the world, one of the main purposes of extension is to increase the level of living standards of the rural family through nonformal education. Extension has a very crucial role to play in sustainable development [14]. Moreover, they are central to realizing the potential of agricultural innovation. Many developing countries, however, do not have sufficient resources to properly develop their capacity for innovation. More specifically, the activities of agricultural research institutions are often affected by scarce investments and poor financial management, as well as limitations in technology transfer strategies [13]. For that reason, to develop and enhance research and extension relations by suitable policy acts. In this context, it is necessary to make a strong effort to ensure that the findings of the research reach the producer as well as to the adoption. It is absolutely necessary to bring research and extension together.

Modern technologies and innovation are very important for rural development of many developing countries; these technologies are developed by research institutes or universities or in the other case imported from developed countries, which are leading in field of research and development. Two factors seemed to be very important for farm operators' technology use on farms: a public and private organization engaged in dissemination of recent innovations and technologies to rural areas and second is socioeconomic characteristics and information seeking behaviors of farm operators, which influence their decision to select information sources of information. It is necessary for farm operators to know about how to carry various framing practices like soil preparation, selection of seed and sowing techniques, fertilizations, disease and pest management, irrigation and harvesting, and storage, for the reason of survival in competitive market and more stable income [15]. Agricultural information systems have very important role in rural development. Besides new information create; professional expert and suitable input via several factors is required to develop. Factors those take place in the list are rural folks, field staff of extension organizations, nongovernmental organizations (NGOs), and research institutes, becoming increasingly popular in many countries local municipal authorities [16]. Despite the fact that rural population requires extension services, training, and access to information, share of budget endowed is very limited around the globe [17].

It is necessary to clarify the topic here. In particular, R&D refers to the process leading up to the introduction of a technology. However, even if it is not prevailing in sector like industry where professional sense is dominant, but there are many difficulties in quickly and timely reaching findings of research to target groups, especially in the agriculture sector of developing countries. It is necessary that the technologies that are produced are derived from the old technology and are used rapidly in the production process. From this perspective, research and extension (R&E) is equally important like research and development (R&D). Because there is risk that developed technologies will remain in libraries or electronic data banks without coming in force. From this perspective, budget, time, and human resources are used at great cost to produce these research findings or output, their effectiveness and dissemination is important. For this reason, R&E is important like R&D [18]. There are many ancient examples, especially of not taking advantage of technologies produced in rural areas. Maximum efforts should be made to ensure that research and extension get equal importance.

5. Conclusion

Human capital is the most important strategic factor for development and also rural development; as new technologies emerge, the market demand for better and healthier products and consumer demand in terms of quality and delivery time are changing. In today's world, it becomes increasingly important to know how information can be accessed, how it is adopted, and how it can be assimilated. In this respect, each country allocates budget for training, education, and extension according to its own conditions. This budget may be intended for rural community-based social assistance, but the economic and welfare effect is essential. In this way, it is aimed to increase the living standards of the families living in the rural areas. This will naturally contribute to national income and to the prosperity of society.

When Turkey is taken as an example to have huge experiences. in 1846, Agricultural education was started in Turkey. However, the main developments on agricultural research and extension have occurred since the 1930s [19]. Generally, it is developing policies to increase public prosperity in the new millennium in the framework of these developments. According to this, since the beginning of 2000, Turkey with its policies has made important leaps in the field of human, science, and technology development. Turkey has made significant even radical changes in science and R&D policies. Between 2003 and 2004, while increasing its National Income from 305 to 800 billion dollar and increasing GDP 2.6 times, Turkey increased it R&D expenditures seven times. Therefore, the share of R&D has increased to above 1% of GDP in 2015, which was 0.48% in 2003. Private sector stands first with 49.8% in R&D expenditures, followed by higher education (40.5%) and public institutions (9.7%). In 2014, 51% of R&D expenditures are financed by commercial sector, 26% by public, 18% by higher education, 3% by other domestic resources, and 1% by foreign sources. Agriculture share in R&D expenditure are 4%, out of 572 million dollar 51% is by public sector, 46% by higher education, and 3% by private sector [20]. As a result, in order to reach 2023 targets, Turkey is determined to carry out its consistent and innovative policies in the science and technology field. With increasing R&D share from 1 to 3% and R&E integrity, it will achieve significant improvements in livestock and crop production sector like other in other sectors.

As a result, all over the world, particularly in developing countries, that R&E is very important and should be considered at least as much as R&D. However, it will be ensured that societies meet with the technology produced. For this, the development of human resources should be emphasized and a suitable atmosphere should be prepared for this widespread prosperity.

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Chapter 3

SMEs Development through Public and Private Partnerships: The Key Role of Research Transfer and Patent Information Analysis

Henri Dou

Additional information is available at the end of the chapter

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Abstract

Innovation is today one of the best ways to improve competitiveness and to create jobs. In this context, the knowledge and competencies developed in academic laboratories and research centers must be transformed into products and services. To achieve this goal, the use of patent information is one of the best ways to understand the areas concerned with the research, to find partners, and often to shift academic subjects to more relevant domains. This chapter concerns patent information retrieval and automatic patent analysis (APA). It shows how the results are useful for the research valorization and transfer, especially to SMEs.

Keywords: patent, APA, automatic patent analysis, PPP, public and private partnership, innovation, SME, transfer, valorization, research

1. Introduction

In two recent articles published in 2016 by "Vie et Science de l'Entreprise," Battini [1] and Dou [2] underlined the necessity to promote the development of SMEs and innovation to develop employment on a large scale. In this chapter, we develop these concepts by outlining the main step of innovation on one hand and on the other hand how this main step can be catalyzed by patent information analysis.

2. The main step in innovation

Many people confound innovation and invention. These two are different; what is important for us is the main step in innovation process as described in the work financed by the European Union and developed by Vinnova [3]. According to this study, innovation is developed in two steps:

- The first step is the financial support of the state to the universities and research centers to create knowledge and competencies.
- The second step consists of transforming these competencies and knowledge into "money" and this is the real main step of the innovation process.

This second step induces various consequences:

- An increasing move toward the development of links between academic research and industry (in our case SMEs).
- The development of public and private partnerships (PPP).
- The valorization of academic research.

In this condition, it seems important to discuss prior to the catalyst aspects of patent information analysis, the brakes and levers, which often prevent the development of industrial relationships between academic research and SMEs. In most countries, the evaluation of the researchers as well as their university or research center is done according to the rating of some top papers published in journals which are seldom read by industrialists. The result is that for an academic researcher, working closer from industry and more specifically from SMEs is a brake to their careers since part of his work will not be devoted (as the expert evaluators will say) to fundamental aspects of research. Various voices rose to describe what was called by Gingras the "bibliometrics fever" [4] and its negative role in the development of multidisciplinary R&D.

Even if we criticized this state of affairs, we are not going to change it. To do so will take a long period of time and a real change in the frame of mind of people. Hence, what we will do is propose a way, while still remaining in the "canons" of fundamental research, to move from this former situation to a new one closer to what the man in the street may expect of the national research output. The objective is not to change the way of conducting research, but to provide the researchers with a way to get closer to industrial applications, and the industrialists a way to open prospective and fructuous discussions with academics. The objective is clear, if nothing is done, the part of the fundamental research which can be transferred to industry will remain small. But if a slight move is done in view of possible applications, more transfers will occur. This aspect of the virtuous spiral between research funding and application is now named social research responsibility (SRR) [5].

A few years ago, Zerouni [6], at that time the director of the NIH (National Institute of Health of the United States), made the following statement: *"The success of American scientific research depends on the existing implicit partnership between academic research, the government and industry.*

The research institutions have the responsibility to develop the scientific capital. The Government finances the best teams by a transparent system of selection. Industry holds the critical role to develop robust products intended for the public. This strategy is the key of American competitiveness and must be maintained." This statement seconds the work of Vinnova in the Interreg III program cited above.

Another problem, when we speak of close relationships between academics and industries, is the multidisciplinary approach. Today most of the industrial problems and developments necessitate a multidisciplinary context. But again, because of evaluation criteria of researchers, the multidisciplinarity is most of the time absent. In a recent issue of Nature [7], a group of authors pinpointed that to solve the world facing problems (pollution, weather change, population, health, starvation, water supply, etc.) needs a close cooperation between various disciplines. "But research that transcends conventional academic boundaries is harder to fund, do, review and publish — and those who attempt it struggle for recognition and advancement. This special issue examines what governments, funders, journals, universities and academics must do to make interdisciplinary work a joy rather than a curse." Industrial cooperation is a good way to promote multidisciplinary research, and patent analysis is one of the best ways to show people why this is necessary and how it can be developed.

2.1. How patent information may change the vision of research

Most of the time, patents are seen by people as a tool to protect a product or an application and then to give a monopoly of exploitation during 20 years. Many considerations on the role of patents in this area have been published [8], but the goal of this chapter is not to look into this aspect but rather into the information that patents provide. One of the largest patent databases available is the world patent database from the EPO (European Patent Office) which provides more than 90 million of patent notices from more than 90 countries. Other databases such as Patent Scope (Word Intellectual Patent Organization, WIPO) or European Patent Database (EPO) or national patent databases (US, Japan, European countries, etc.) are available via Internet and are free of charge. This tremendous amount of information provides a living technical encyclopedia always up to date which provides information in areas described in detail in the Glossary of Patent Terminology [9, 10]. The fields available and useful in patent analysis are indicated in **Table 1**.

The information which is provided by the patents is very important since the patent information bridge the gap between fundamental research and markets. In this condition, patents are a perfect tool to begin to answer one of the first questions that a researcher should ask: How useful is my research [11]? Generally, people in research know the fundamental purpose of their work (even if it is the continuation of a specialty useful at a certain time but obsolete today), but because research is vertical, they do not embrace all the whereabouts of their subject, especially on the application point of view. One of the best examples of this situation appears when one examines the references in a scientific paper. Most of the time you will not see a patent cited as a reference. This pinpoints the gap which exists between fundamental research and industry. The situation is not the same on the patent side since in US, European, and World Patents the examiners often cite the so-called "non-patent literature," which is most of the time scientific papers.

Type of data	Description	Usefulness
Title TI	Title words	Describe shortly the patent purpose
Applicant(s) AP	Patent owner(s)	Knowledge of new entrants, main leaders, old timer. Useful to establish contacts or to examine the company site
Inventors IN	Inventors	Can be the same as applicants. Useful to establish contact, or to trace the people on Internet or social networks
Abstracts AB	Describe the patent purpose	Useful for a quick view of the patent coverage
International Patent Classification IPC	Describe the technologies or applications. From 1 to 8 digits according to the precision	Technology mapping, technology trend, application areas, and so on
Application date	The patent application date is the date on which the patent office received the patent application	The two first digits represent the country. Searches can be done to find a specific patent or the patents from the same country, for example, FR* *=truncation
Priority date PR	The filing date of the first application is considered the “priority date”	Date from which the protection starts. Delay of extension of the patent to other countries, 12 months from the PR
Priority country	Country where the patent is first filed before being (possibly) extended to other countries	Allows to search by country using the first two digits and the truncation
Claims	These define the invention that the applicant wishes to protect	Help to understand the scope of the patent
Description	Details on the patent	Describes the patent in detail
Drawing(s)	Complement of the patent description	Help the expert to understand the patent description
Citations	Examiner(s) of patent scientific and technical novelty may cite other patents or non-patent literature relevant to the patent examined	Help to gather patents related to the same invention or to detect among these patents the ones which are the most important (the most cited)
Span of a patent	Generally 20 years	After 20 years, the patent is in the public domain

Table 1. Information provided by patents.

Patent information is then a good way to break the “technical illiteracy” of some people and it will help to “open the window” through which the researcher can understand the facets related to his research. Today, there are no barriers to use these facilities, and most of the patent databases are available on the Internet. This is not a question of facility, this is a question of good will and also to develop some indicators which will evaluate the researcher’s output in a better way. The new role of university is not only to teach and to search, but also to help its environment to become more prosperous.

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2.2. The positioning of a research topic

Most of the time when a researcher enters into a research laboratory to get a PhD or to be hired as a full-time researcher, he will continue a research closely linked to the laboratory specifications. This is the general rule since the laboratory wants to comfort its position. But doing so, various aspects of the subjects will not be clearly understood. This is because of the vertical specialization and because some subjects may need a multidisciplinary approach. This sort of "technical illiteracy" has been analyzed and the role of patent information as a way to clean it has been underlined [12]. One of the examples of this situation is given by the content of the bibliographies of scientific papers where almost no patent citations can be found. This underlines the gap which exists between academic research and the industrial world. But in the World Patents (PCT), European Patents, and US patents, the examiners often cite information coming from the non-patent literature, pinpointing the links between research and application. The same situation occurs in chemistry when people look for a protocol of synthesis of some products. They go to classical academic literature forgetting that very detailed synthesis protocols may be found in the patent literature.

2.2.1. Example

Example: A laboratory specialized in heterocyclic synthesis is interested in the various processes available to produce 4-methyl thiazole and 4-methyl thiazole derivatives. It can find some answers to these two questions by making a rapid search on the world patent database. There are syntheses already described in classical scientific papers [13] and, if not patented, they are in the public domain and concern mainly research. What we are looking for is the trend in industrial chemistry of the synthesis patented by companies in that domain.

Query: "4-methyl thiazole" AND (preparation OR synthesis) in the patent titles (to be more precise) from 1930 to date (November 2016). The brackets are used to indicate that this is a string search with only this expression.

Note that the formulation of the question will also give the 4-methyl thiazole derivatives.

12 patent families are selected covering 20 patents; out of them two patents can be selected:

Patent number: US4284784A Preparation of 4-methyl thiazole

Legal status: Unknown

Publication date: 1981-08-18

Applicant(s): Merck & Co Inc

Inventor(s): Ho Sa V

Priority number: US15228280A 19800522

Application number: US15228280A 19800522

CPC: C07D277/22

IPC: C07D277/22

English abstract: An improved process for the preparation of 4-methyl thiazole is disclosed. The process utilizes a substituted imine and sulfur dioxide heated in the presence of a catalyst. The thiazoles are important chemical intermediates.

Non-patents literature: Adams, Journal of Catalysis II. 1968;pp. 96-112

Colebourne et al., Journal of Chemistry. 1968;pp. 685-688

English title: Synthesis of 4-methyl thiazole

Titre Français: Synthese De 4-methylthiazol

Patent Number: CA2053428A1

Legal Status: Unknown

Publication Date: 1992-04-16

Applicant(s): Merck & Co Inc

Inventor(s): Gortsema Frank P, Sharkey John J, Wildman George T, Beshty Bahjat S

Priority Number: US59763990A 19901015, US76703091A 19911001

Application Number: CA2053428A 19911015

CPC: C07D277/22, B01J29/40, B01J2229/26, B01J2229/42

IPC: B01J29/035, B01J29/40, B01J29/70, B01J29/80, C07B61/00, C07D277/22

English abstract: Isopropylidene methylamine is reacted with SO_2 to form 4-methyl thiazole in the presence of a modified zeolite catalyst that has been ion-exchanged with an ammonium salt and porefilled with an alkali metal salt.

Further information about the protocol of synthesis can be found in the patent description also available online. Also note the presence of the non-patent literature.

Also note that the citing documents (available with the same search) are the patents published after 1981 and which cite this patent. This not only provides further information but also indicates that the cited patent is important. This patent is from 1981, this means that it is now in the public domain and can be used freely.

Access to 4-methyl thiazole derivatives may also be selected from the results:

AU3280178A - 2-isopropyl-4-methyl thiazole for fruity flavor, etc.

2.3. The methodology

In the example above, the number of patents selected is small because the subject is very restrictive. But because the patent number increases every year, many patent searches give a larger

http://dx.doi.org/10.5772/intechopen.69072

set of answers. This is due to the methodology which is used to understand all the whereabouts of a subject in contrast to the “classical documentation searches” where the goal is to obtain a very precise answer with the least possible noise. In our case, a largest query ensures that all the “contours” of the subject will be “inside the results” of the search. Then, after the query results, the question will be: how to be able to deal with this large amount of patent notices, which often goes up to 1000 or more. This problem can only be solved by coupling to the system of query a system of automatic analysis. This is what is called automatic patent analysis (APA). The following presentations and analysis are done with the Patent Pulse software [14].

The principle of the APA is the following:

Make a query on the remote patent database, download the results, and at the same time format the patent notices to be able to perform the various correlations: charts, matrix, and networks to understand the classical questions: who is doing what, how, with whom, when, why, and so on. **Figure 1** indicates the two ways to deal with the problem:

- To have a permanent software on your computer and to create a downloaded database on your local computer and then to perform the analysis locally.
- To use your computer as a terminal and do the same things on a remote computer and access and store the results, if necessary.

In the external mode, cooperative work is privileged, but with a total privacy between users who share their data. When a firm gets a license, this license may concern one or more users. These users may exchange results and data stored in one or several folders created by the users upon acceptation of the “exchange demand.” These exchanges, even if the users belong to the same company, are only visible to the users engaged in this exchange. When different firms get a license, these licenses may concern one or several users per company. In this case, the same process as above may occur between various users. If any user wants to contact somebody without a license, the exchange is possible. In this case, you will not go through the platform, but you will be able to exchange a patent notice (with or without your proper comment) using your email (this option is native within the platform). The two types of systems are presented in **Figure 1**.

Then, if we go back to the search concerning the 4-methyl thiazole, in the same time that the results (patent families) appears on the screen, you will find on the right side of the screen boxes charts of dates, inventors, applicants, and so on. The left part of the screen deals with your own results and the results which are shared with other people. The right part of the screen deals with the various histograms of dates, inventors, applicants, IPCs, and so on. On the top right of the screen, indications concerning notification of all the alerts on various subjects, connection(s) pending or real with Patent Pulse users, help, tutorials, and account can be seen. On the middle of the screen, the results of the search are indicated. Clicking on one patent opens a window which contains the bibliographic data, the abstract, the patent family, the cited patent(s), the non-patent literature, the patent status, the claims and the description, the INPADOC [15] status, and a link to access the full text of the document. The main screen of the Patent Pulse system is presented in **Figure 2**.

The correlations to see who is doing what: (between applicants and IPC) or what is the network of inventors, or applicants/inventors, etc., can be done by selecting the corresponding

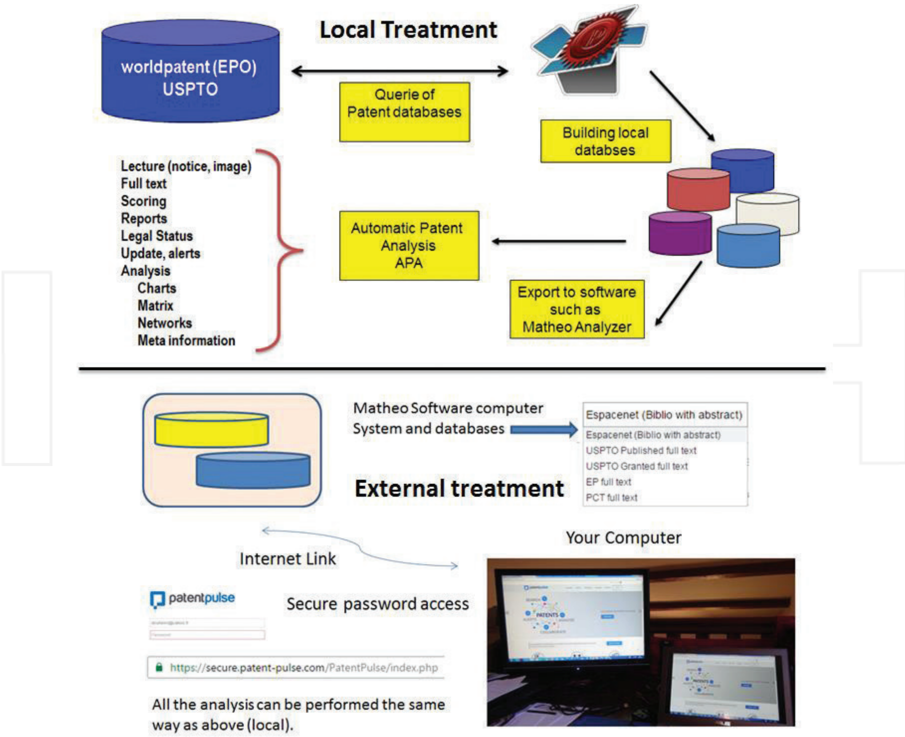


Figure 1. The two ways to perform automatic patent analysis (APA).

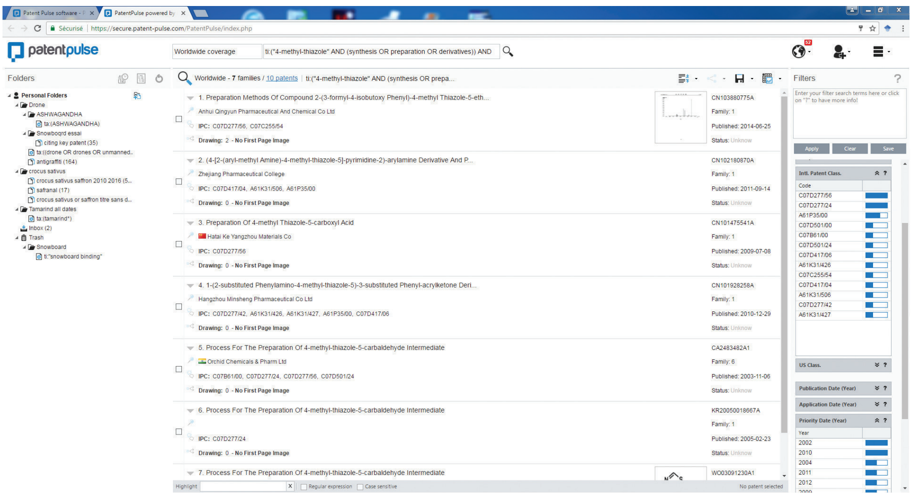


Figure 2. Main screen of Patent Pulse.

options (top right of the screen). **Figure 2** shows the full screen of the Patent Pulse application after the query. It is important to note that as the access to the patent database is free, the only charge is a subscription to the APA software (local or external). In case of the external option (Patent Pulse), there is no need to install a software on your computer (as for Matheo Patent) and there is no problem with the computer administration.

The bibliometrics treatment of patent information has been the purpose of various scientific publications which present in detail all the methodology and results in various areas of science. See for instance the book Risks Diagonal and Innovation [16] as well as the use of APA in developing countries [17] and more specific applications such as the Avian Influenza [18] or natural resource such as the *Moringa oleifera* [19]. In the following part of this chapter, we present an example underlining the potential of the method and using the facilities which may improve the academics and industrial cooperation.

2.4. Examples

We take a real example concerning a very hot topic: drone(s) and agriculture. The drones are now used in many fields, but one of the most promising is agriculture. In this area, it is interesting to know the main actors (inventors and applicants), the new entrants, the trend in the technology development, etc. Using the patents to answer this question is the best approach since patented applications represent the “state of the art” close from applications. Many laboratories work on the development of more or less sophisticated drones; the patent search (here in the area of agriculture, but which can be extended to many other fields) is a real companion of the researchers.

2.4.1. Materials and methods

The database used is the world patent database available from the EPO. The software used to perform the query and the analysis is the software Patent Pulse. The query was done on 29 November 2016.

Query drone* in titles, and B6* as IPC (International Patent Classification dealing with transporting) from 1970 to 2016

stands for a truncation B6 = Generating or Transmitting mechanical vibration in General

Mind if using the term drone in agriculture field since drone also means some biological species related to bees. Using the B6* IPC avoid this interference.

2.4.2. Results

We selected 404 families covering 560 patents.

Figure 3 indicates the first page of Patent Pulse with all the results (short bibliographic data). Note the presence of the drawings which are automatically extracted, clicking on a drawing enlarges it. This is a great help for technical experts. By clicking on the title of a patent, the expanded bibliography is shown.

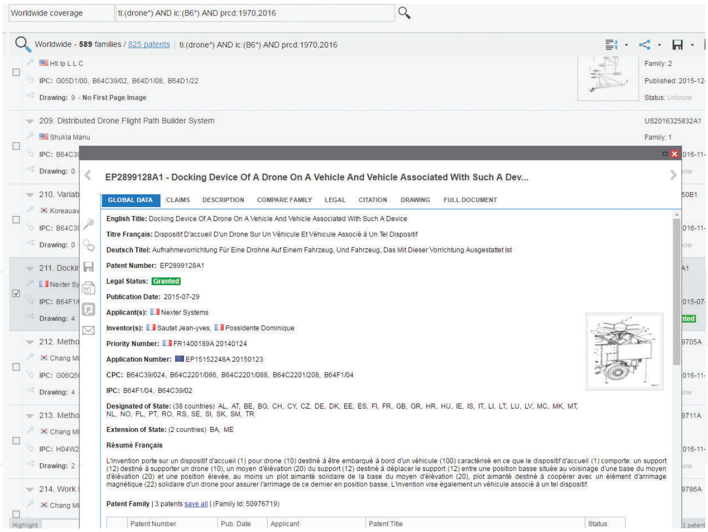


Figure 3. Results from one of the extended patent notices.

2.4.3. *Analysis*

The automatic analysis of the corpus is necessary since the number of patents is too large to do manually. We are going to answer in the analysis the classical questions who is doing what, when, where, for which purpose, and so on.

Trend in drone and transporting: We select on **Figure 4** for the main frequencies of publication per year and this will automatically build up the chart.

The main applicants: Same as above, the selection of the main applicants is presented in **Figure 5**.

In this field, it is interesting to see if some universities are working in this area and if there are some partnerships between applicants. This is done by drawing the network of applicants as indicated in **Figure 6**. All the parts of the network can be enlarged if necessary. We show how the interactions appear on the screen (points which are linked). In **Figure 6**, the dots alone represent an applicant with no link.

We can magnify the various links to see the applicants engaged in the interactions as shown in **Figure 7**.

In **Figure 7**, the links between applicants are magnified; we can note, for instance, that two patents have been published jointly by “Puy du Fou International and Act Light Design,” and so on.

The different fields of application: Detecting the fields of application can be done in two ways: we can use the list of IPCs present in each patent or the user can extract from the titles

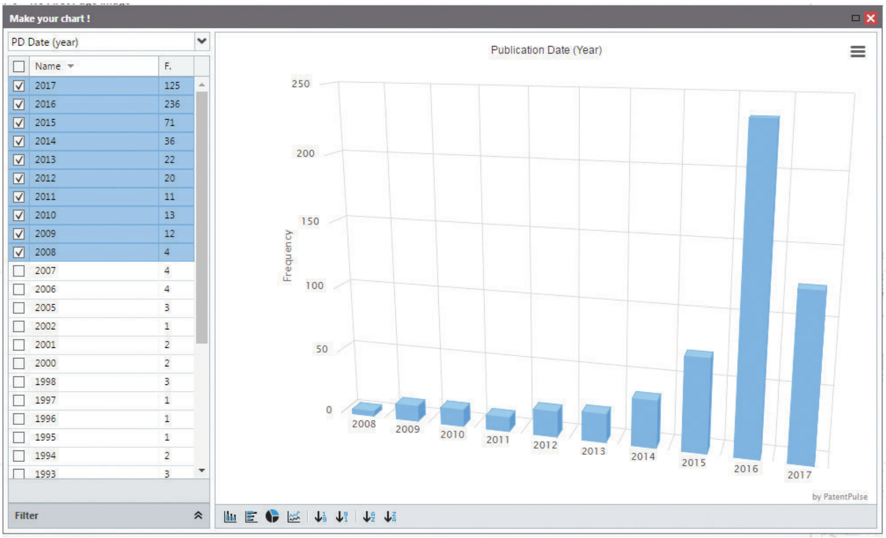


Figure 4. Trend in drone(s) transporting.

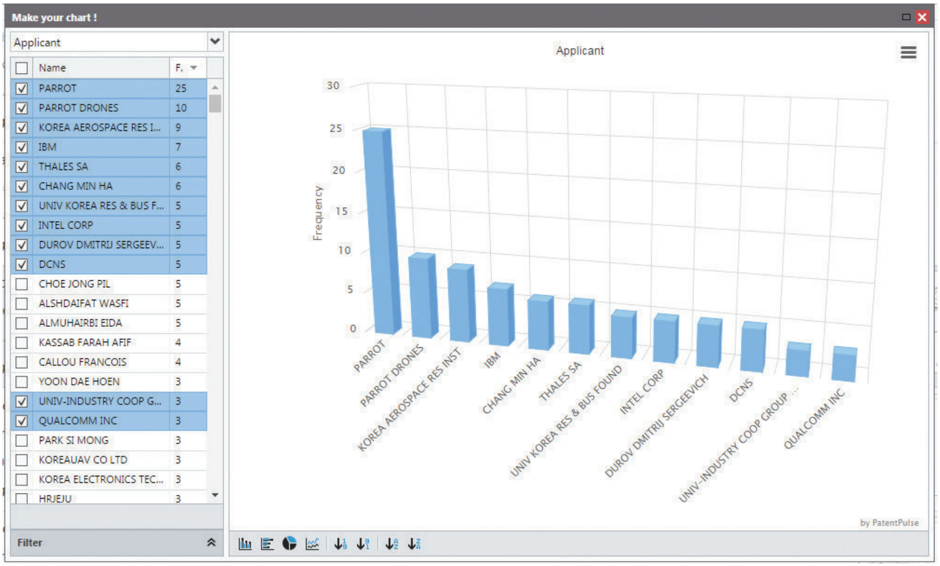


Figure 5. The main applicants.

and abstracts the most significant words and build a group from the relevant patents. **Figure 8** represents the main IPC selected as indicated in **Figure 8**. The IPC 4 is selected because this gives the best compromise. For a most precise analysis, IPC full can be used.

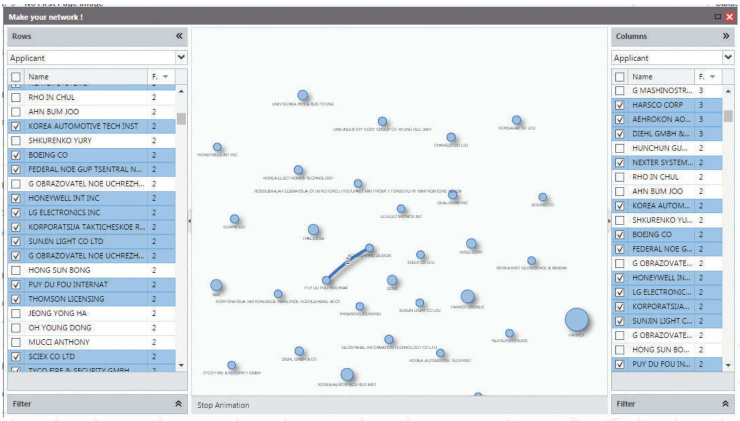


Figure 6. Building up the links in the network applicants/applicants.

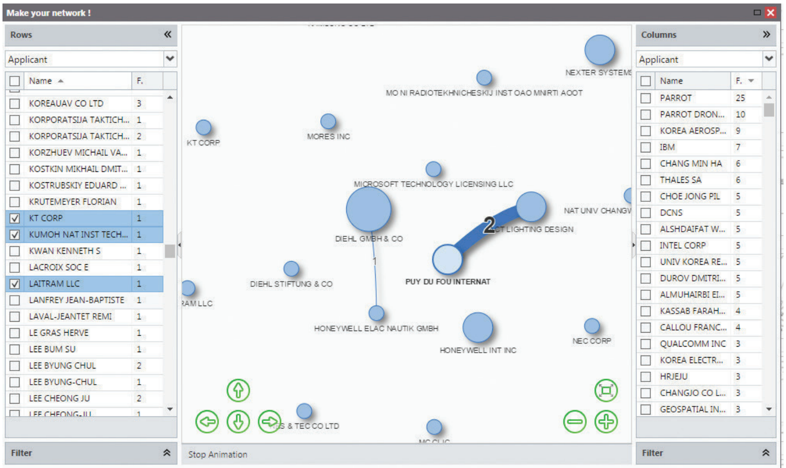


Figure 7. Links between applicants.

The meaning of the IPC can be easily found on the EPO site [20], as shown in **Figure 9**. Working on titles or abstract words can be done by exporting the list of patent notices in a more sophisticated software (for instance Matheo Analyzer), or by exporting the title words or abstracts to an excel file, and so on. In the following example, we selected the term "underwater." This allows to select 10 patent families covering 17 patents.

The main companies involved: Diehl Gmbh & Co, Thales Sa, Dynamit, Nobel Ag, Honeywell Elac Nautik Gmbh, Wardle Patrick (individual inventor), Heinscher Ingo (indivudal inventor), DCNS, Howaldtswerke Deutsche Werft, Diehl Gmbh & Co., US Naval are the main companies involved, see **Figure 10**.

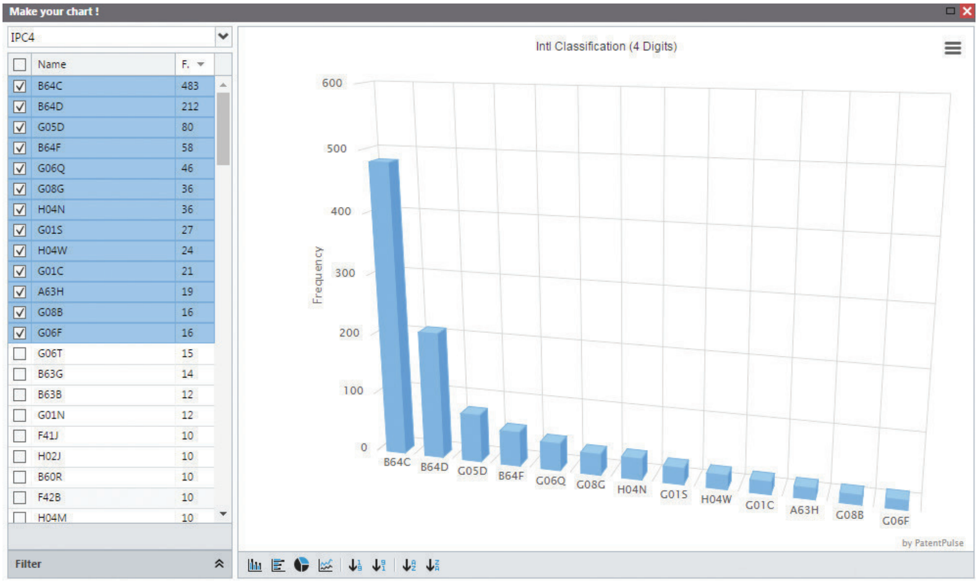


Figure 8. The main IPC 4.

	TRANSPORTING
B60	VEHICLES IN GENERAL
B61	RAILWAYS
B62	LAND VEHICLES FOR TRAVELLING OTHERWISE THAN ON RAILS
B63	SHIPS OR OTHER WATERBORNE VESSELS; RELATED EQUIPMENT
B64	AIRCRAFT; AVIATION; COSMONAUTICS
B65	CONVEYING; PACKING; STORING; HANDLING THIN OR FILAMENTARY MATERIAL
B66	HOISTING; LIFTING; HAULING
B67	OPENING, CLOSING {OR CLEANING} BOTTLES, JARS OR SIMILAR CONTAINERS; LIQUID HANDLING (nozzles in general B05B; packaging liquids B65B, e.g. B65B 3/00; pumps in general F04; siphons F04F 10/00; valves F16K; handling liquefied gases F17C)
B68	SADDLERY; UPHOLSTERY

Figure 9. Meaning of the IPCs.

The difference between the fields of research and application: for each applicant, the difference can be done via a matrix applicant(s)/IPC. This is presented in **Table 2**.

The network between applicants and inventors will represent partly the potential involved in R&D as well as the cooperation between applicants. This is presented in **Figure 11**. Note the link done between the two German companies via common inventors. These key inventors are important if you want to select people with the best R&D knowledge.

Inventor's competencies: Instead of using titles or abstract words or IPC, it is possible to differentiate the inventor's competencies by using the WIPO fields [20]. They are keywords

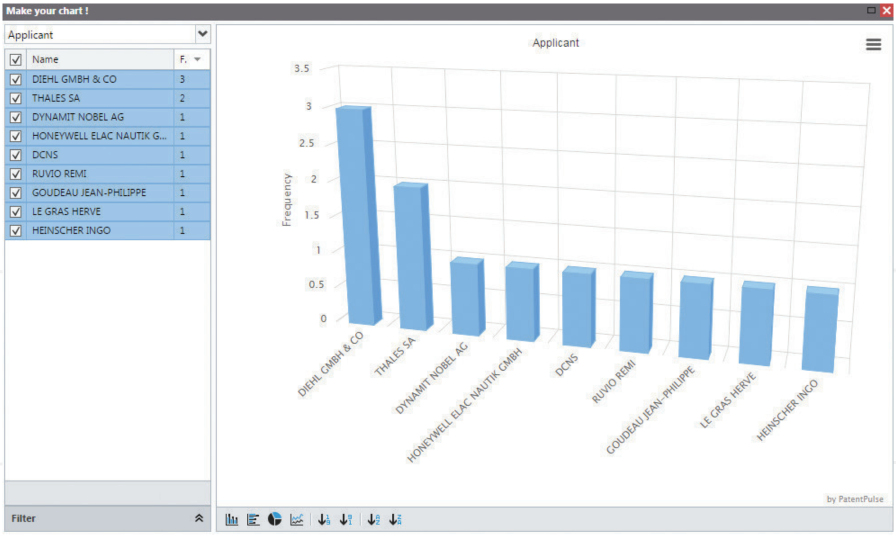


Figure 10. Main applicants drone(s) underwater.

which describe various fields of application of patents. **Figure 12** presents the results of the analysis.

Further patent information: Another type of information can be obtained from the World, US, and European Patents. This can be done by using the patent's citations. These patents contain a field called cited patents (patents cited in the patent examined) or citing patents (patents where the patent concerned is cited). All the patent citations are done by the examiners of the patent office. For instance, the patent EP1798145A3 is indicated in **Figure 13**.

Now, if you want to know what are the patents linked by the citations to the US patent US7631611B1 you can easily expand the network by clicking on the patent (presented in **Figure 13**) and expanding the network as shown in **Figure 14**.

In this way, it is possible to build up a cluster of patents that are related to one important patent [21] and then to know all the different R&D orientations of this invention. In **Figure 14** the patent EP1798145 is present in two different levels of examination: A2 and A3, the meaning of this being available in reference [22]. For the US patents the meaning of the various levels of examination called "kind codes" is available in reference [23].

2.5. Conclusion

Even if all the application of automatic patent analysis (APA) cannot be developed because it will take too long, the usefulness of the patent information is demonstrated. The knowledge of the leaders, of the new entrants in a field, the trend in time and technology development, the links between the actors, the types of patents, and their country's coverage are significant points which help to have a clear view of what is going on in a given area. The patent information

	B63B27	B63C9	B63C2009	63G3	B63G5	B63G6	B63G7	B63G8	B63G2008	B63H21	F42C14	F42C15	Y02T70	Y02T90
HONEYWELL ELAC NAUTIK							1							
DCNS								1						
WARDLE PATRICK		1	1					1	1					
DIEHL GMBH & CO				1	1	1	3	1						
DYNAMIT NOBEL AG							1				1	1		
HEINSCHER INGO								1		1			1	1
THALES SA	1													
Grand total	1	1	1	1	1	1	5	4	1	1	1	1	1	1

Table 2. Difference between applicants.

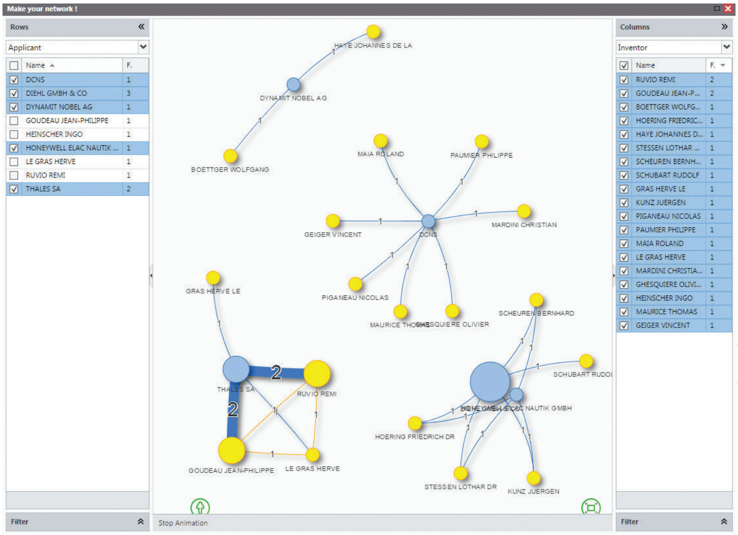
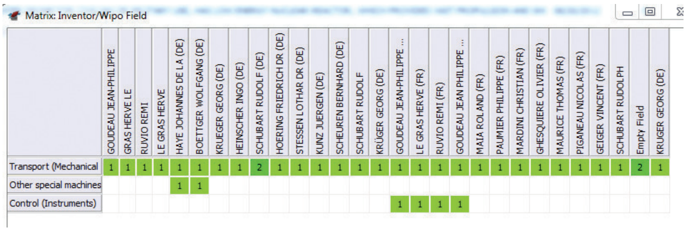


Figure 11. Network of the main applicants with the network of inventors.



Matrix: Inventor/Wipo Field

	GOUDEAU JEAN-PHILIPPE	GRAS HERVE LE	RUVIO REMI	LE GRAS HERVE	HAYE JOHANNES DE LA (DE)	BOETTGER WOLFGANG (DE)	KRUEGER GEORG (DE)	HEINSCHER INGO (DE)	SCHUBART RUDOLF (DE)	HOERING FRIEDRICH DR (DE)	STESSEN LOTHAR DR (DE)	KUNZ JUERGEN (DE)	SCHEUREN BERNHARD (DE)	SCHUBART RUDOLF	KRÜGER GEORG (DE)	GOUDEAU JEAN-PHILIPPE ...	LE GRAS HERVE (FR)	RUVIO REMI (FR)	GOUDEAU JEAN PHILIPPE ...	MAIA ROLAND (FR)	PAUMIER PHILIPPE (FR)	MARDINI CHRISTIAN (FR)	GHESQUIERE OLIVIER (FR)	MAURICE THOMAS (FR)	PIGANEAU NICOLAS (FR)	GEIGER VINCENT (FR)	SCHUBART RUDOLPH	Empty Field	KRUGER GEORG (DE)
Transport (Mechanical	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1
Other special machines					1	1																							
Control (Instruments)																1	1	1	1										

Figure 12. Competency differences between inventors.

is also interesting for developing countries which may find, in patents, in the public domain, technological information enabling them to develop useful products and services. For the academics, patents are a natural link between science—technology and markets. This is one of the powerful catalysts to move the research subjects closer to applications. Because the cost of the patent notices is free, the cost of APA software is affordable for academics, SMEs, and even individuals. Facilities available with the APA platforms enable the users to share various topics and to discuss and comment the most important analysis and key patents. This will help to move toward a multidisciplinary approach of research and development. Another point which has not been discussed here is the role of APA in preclustering. When it is necessary to develop clusters (or poles of competitiveness in France) in certain domains, it is necessary to show to the stakeholders what could be the R&D contours of the future cluster. To do so, APA is fundamental because that will show clearly what the "other or possible competitors" do and then what can be developed by linking all the stakeholder knowledge and facilities together. Various examples of this strategy were developed in scientific papers especially for the developing countries [24, 25].

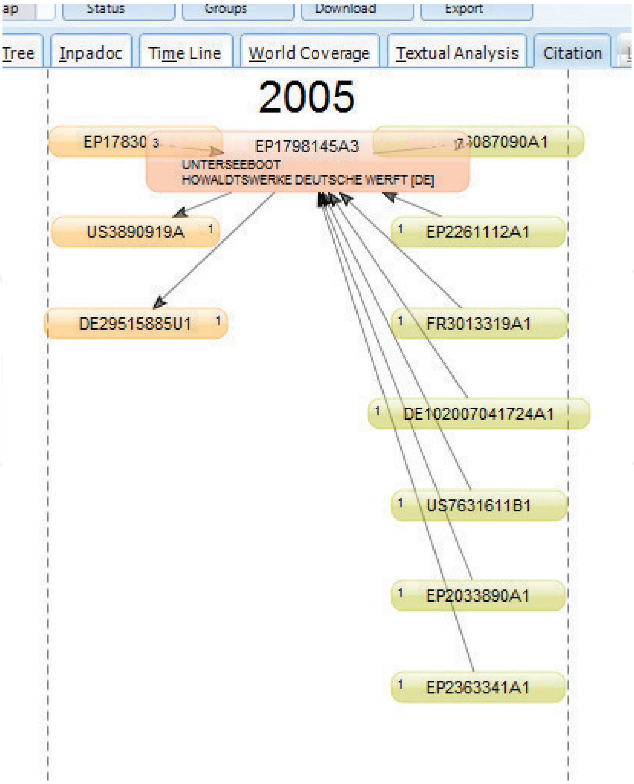


Figure 13. Citation network of the patent EP1798145A3.

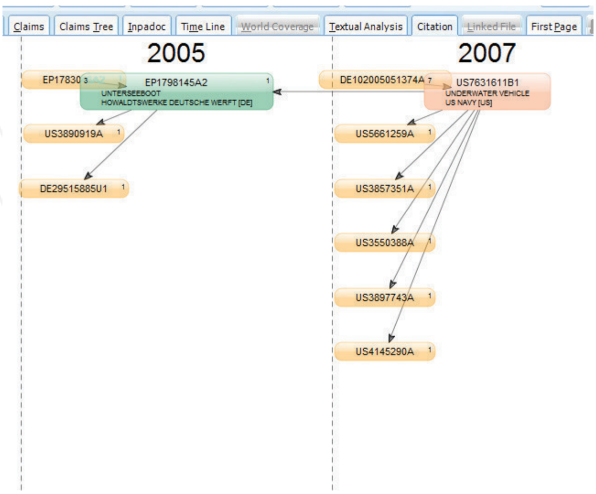


Figure 14. Expansion of the network of **Figure 13**.

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INTECH

Chapter 4

Smart Microgrids: Optimizing Local Resources toward Increased Efficiency and a More Sustainable Growth

Wilfried Elmenreich, Tamer Khatib and
Andrea Monacchi

Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/intechopen.69369

Abstract

Smart microgrids are a possibility to reduce complexity by performing local optimization of power production, consumption and storage. We do not envision smart microgrids to be island solutions but rather to be integrated into a larger network of microgrids that form the future energy grid. Operating and controlling a smart microgrid involves optimization for using locally generated energy and to provide feedback to the user when and how to use devices. This chapter shows how these issues can be addressed starting with measuring and modeling energy consumption patterns by collecting an energy consumption dataset at device level. The open dataset allows to extract typical usage patterns and subsequently to model test scenarios for energy management algorithms. Section 3 discusses means for analyzing measured data and for providing detailed feedback about energy consumption to increase customers' energy awareness. Section 4 shows how renewable energy sources can be integrated in a smart microgrid and how energy production can be accurately predicted. Section 5 introduces a self-organizing local energy system that autonomously coordinates production and consumption via an agent-based energy auction system. The final section discusses how the proposed methods contribute to sustainable growth and gives an outlook to future research.

Keywords: smart microgrids, sustainability, smart home, renewable energies

1. Introduction

1.1. Motivation

While our energy system has been considerably stable in its components and operation over several decades, the need for integrating sustainable energy resources and for making the system more efficient requires a major change of the energy system on all levels.

Sustainability is a concept that touches many aspects, which often makes it difficult to define its application in a limited domain. For example, in energy generation, photovoltaics (PV) provide an attractive means of a zero-carbon energy source, but when looking at it through a sustainability lens, the energy and resource usage during production of the panels has to be considered as well. While a growing importance of sustainability is to be welcomed, this has also led to an inflationary use of the term sustainability which has been reportedly pointed out [1]. For instance, Google books Ngram Viewer[1] reports an increasing use of the term "sustainability" by a factor of one thousand between 1970 and 2008 (the most recent accessible year).

Keeping in mind that sustainability means include the combination of many aspects, we want to show a number of different means in the context of electric energy systems in this chapter, evolving around the concept of a smart microgrid. This transition to a low carbon, affordable energy system, also coined Energiewende based on continuous efforts since the 1980s in Germany aiming at a cleaner energy system, requires new technologies and new control strategies. This involves also putting the user into the loop, either by having people directly acting based on some feedback system or by learning the users' needs and optimizing an energy management system in a way that it can act on a user's behalf. Such a system is inherently complex, since it involves many aspects starting from meteorologic parameters influencing PV and wind generation up to economic models related to energy markets and finally the psychology of users regarding their experienced comfort or discomfort. Thus, there is a strong motivation for approaches that can handle the complexity of optimizing resources of an energy system toward increased efficiency and a more sustainable growth. In the following, we address these problems from several viewpoints and depict solutions based on smart microgrids.

1.2. Smart microgrids

Microgrids provide a bottom-up approach to cope with the arising complexity and volatility added from the increasing use of renewable energy sources. A microgrid can provide better coordination and resource utilization, better integration of renewable energy sources, improved economical revenue and privacy protection. A microgrid is a system comprising one or more units for energy generation, energy consumption and, possibly, one or more units for energy storage. For example, a smart microgrid could contain a PV array, a household with electrical devices and batteries for storage. Microgrids can be grid-connected or off-grid, and it is also possible that a microgrid can operate in both modes. A smart microgrid contains

[1]http://bit.ly/1J09dv4.

local control intelligence to operate and coordinate its components. With this in mind, we can assess components of a microgrid based on the possibility to control their power. Renewable energy sources such as PV systems or wind turbines provide only a limited possibility of control, since they are normally operated to provide their maximum output (e.g., operating at the maximum power point of a PV array). While it is possible to reduce their output (e.g., operating a PV array off the maximum power point or using feathering in a wind turbine), this is no good strategy in economic terms since the energy not retrieved cannot be recovered later. Energy consumers allow limited controllability given that they can be controlled (see the concept of a smart appliance [2] for particular approaches and issues) and that the comfort loss for the user is acceptable [3]. Energy storage can operate as a consumer (given that the storage is not full) and as a provider of energy (given that the storage is not empty). While, in general, a storage allows a larger time frame for the balancing between energy generation and consumption, it also comes with additional complexity for finding the right control strategy and for defining the optimal size for a storage.

While smart microgrids come with the advantage of being a small system in comparison with the overall energy grid, the small size also comes with new challenges. For example, a microgrid requires a tighter coordination of its components since the law of large numbers does not apply for them. This also means much less inertia and therefore smaller timescales in its control systems. While a large synchronous grid comes with timescales of minutes that can be handled by a human operator, a small microgrid could have a timescale of milliseconds, thus requiring a fully automatic system for its control. Current trends in smart microgrid research therefore include automatic and self-organizing control systems, prediction of renewable energy sources, stabilizing microgrids by adding storage or designing DC microgrids to better address the nature of PV produced energy and batteries. An energy management system for a smart microgrid aims at controlling a microgrid in order to fulfill a given objective. Objectives could be maximizing renewable energy usage, maximizing revenue, maximizing user satisfaction, giving user feedback or protecting privacy by obfuscating the power consumption at the grid connection point [4].

2. Investigating energy usage

Energy usage entails complex dynamics which need to be understood in order to offer effective energy conservation and management strategies. Specifically, to enable research on energy management and sustainability, it is important to build upon publicly available datasets. This allows for assessing solutions before their actual deployment, while still guaranteeing that they work for the real world. In this section, we explore existing energy datasets with the aim of offering an exhaustive comparison of previous measurement campaign and findings. We report of a completed research project addressing energy conservation in Austria and Italy. In particular, we discuss an initial survey carried out to identify common scenarios (e.g., in terms of used devices, diffusion of renewable energy generation) [5]. We then focus on the GREEND dataset, which we collected during a year-long measurement campaign in the regions of study [6]. The dataset was used in our research to model the operation of household appliances, particularly in terms of usage mining and load disaggregation [7], and the problem of determining running devices from an overall power measurement [8].

2.1. The MONERGY project

The MONERGY project aimed at proposing solutions to reduce residential energy consumption in the Austrian region of Carinthia and the Italian region of Friuli-Venezia Giulia. This required firstly the identification of commonalities and differences in terms of scenarios and lifestyle. Therefore, we carried out an analysis of the devices responsible for most consumption so as to derive typical consumption scenarios in the regions. Specifically, we conducted a web survey targeted to residents of the area under study being older than 18. The survey was offered in Italian and German, required approximately 15 min to be completed, and consisted of 43 questions concerning five main sections: (i) household information, (ii) use of electrical devices, (iii) sensitivity toward energy consumption and renewable energy generation, (iv) sensitivity and expectation toward energy management systems, and (v) demographic information. The collected 397 responses were cleaned and resulted in 325 usable ones, namely 186 from Carinthia (96 F and 90 M) and 139 from Friuli-Venezia Giulia (63 F and 76 M). The analysis of collected survey data reported in Ref. [5] provided further insights on the consumption scenarios across the regions. In particular, we identified a greater share of electrical devices, namely hobs, heaters and boilers in Carinthia and contrarily a greater adoption of gas-powered devices and air conditioners in FVG. The study also showed a still limited diffusion of renewables (7.91% in FVG and 2.69% in Carinthia), as well as in billing mechanisms. Because of the already completed rollout of digital meters, residents of FVG are billed under a time-of-use tariff plan (mainly distinguishing nights from day, as well as weekends), while in Carinthia yearly metering and billing is still the norm. As a consequence, we observed that residents in FVG are already benefitting of time-of-use tariffs to exploit more favorable pricing conditions when operating their devices, namely their washing machine (62.59%), lights (24.46%), iron (22.3%), electric oven (21.58%), dryer (10.79%), conditioner (10.07%) and dishwasher (9.35%). The main countermeasure to increase efficiency in Carinthia is device replacement, done by 67.20% of respondents in the previous 4 years, although Carinthians expressed their willing to exploit more favorable pricing schemes, mainly to operate their washing machine (48%), electrical boiler (23%), and dryer (20%). The analysis was continued in Ref. [9] with an estimation of energy usage and an assessment of residents' attitude toward energy management systems, as well as in Ref. [10], where building information was used to extract models of the dwellings (e.g., in terms of number of floors, area) to be used to optimally size the communication infrastructure of an energy monitoring system.

2.2. Collecting energy data

Energy management is only possible after the collection of energy consumption and production data. In particular, we deal with the following physical quantities: (i) the voltage expressed in volts, (ii) the current (i.e., the quantity of charge per second) expressed in amperes, and (iii) the phase shift between these two measures. To collect digital measurements, the amplitude of a signal can be lowered with a voltage divider and fed into an analog-to-digital converter

(ADC) to extract its voltage value. The current can be measured using a Hall-effect sensor or a current transformer, that are transducers converting the magnetic field generated from the flowing current into a proportional output voltage, which can be similarly fed into an ADC and stored as digital value. Contrarily, the phase shift (phi) is the time shift between the measured voltage and the flowing current, and is generally estimated using numerical methods. It is important to remark that datasets for energy management commonly deal with power measurements, which can be distinguished in three different quantities: (i) an active or real power measured in watts (W), a reactive power specified in reactive-volt-amperes (VAR) and (ii) an apparent power expressed in volt-amperes (VA), related as follows:

- P [W] = $V_{RMS} \cdot I_{RMS} \cdot \cos(\text{phi}_{vi})$
- Q [VAR] = $V_{RMS} \cdot I_{RMS} \cdot \sin(\text{phi}_{vi})$
- S [VA] = $V_{RMS} \cdot I_{RMS}$

The root-mean-square value (RMS) of a signal can be computed by dividing the peak value by the crest factor, a signal-specific property. For a sinusoidal signal, this is for instance $\sqrt{2}$ while it is $\sqrt{3}$ for a triangular one. Another important matter when measuring electrical signals is the sampling frequency, which according to the Nyquist-Shannon theorem should be greater than twice the highest frequency in the measured signal, in order to avoid the aliasing effect, in presence of which it is impossible to reconstruct the original signal.

2.3. Energy datasets

Energy datasets are necessary to allow for the assessment of solutions on real scenarios and consequently allow for comparable and reproducible research. We report a survey of existing datasets in **Table 1**.

Collected features are: active power (P), reactive power (Q), apparent power (S), energy (E), frequency (f), phase angle (phi), voltage (V), current (I), and power factor (pf). Remarkably, datasets can be classified as those that monitor only a limited number of buildings at a high sampling frequency (e.g., REDD and BLUED), those collecting data from individual devices without providing any building information (e.g., Tracebase and ACS-F1), and those providing a high number of locations for statistical validity (e.g., HES and OCTES).

2.4. The GREEND dataset

The GREEND dataset was carried out within the activities of the MONERGY project to overcome the limits of existing datasets and offer a framework for a better understanding of the regions of study. As previously shown in **Table 1**, the dataset consists of more than 1 year active power data (P) collected in eight households at 1 Hz resolution. In particular, the dataset includes the following:

- House #0 a detached house with two floors in Spittal an der Drau (AT), whose residents are a retired couple, spending most of time at home. Monitored devices include a coffee machine, a washing machine, a radio, a water kettle, a fridge with freezer, a dishwasher, a kitchen lamp, a TV and a vacuum cleaner.

Dataset	Location	Duration	Buildings	Sensors	Features	Resolution
ACS-F1	Switzerland	1 h	N/A	100	*I*,*V*,*Q*,*f*,phi	10 s
AMPds	Canada	1 year	1	19	*I*,*V*,pf,*f*,*P*,*Q*,*S*	1 min
BLUED	USA	8 days	1	1	*I*,*V*, switch	12 kHz
ECO	Switzerland	8 months	6	6–10 sub	*P*, Occupancy	1 Hz
GREEND	Austria, Italy	1 year	8	9	*P*	1 Hz
HES	UK	1 month to 1 year	251	13–51	*P*	2 min
iAWE	India	73 days	1	33	*V*,*I*,*f*,*P*,*S*,*E*,phi	1 Hz
IHEPCDS	France	4 years	1	3	*I*,*V*,*P*,*Q*	1 min
OCTES	Fi, IS, SCO	4–13 months	33	1	*P*, price	7 s
REDD	USA	3–19 days	6	9–24	Agg: *V*, *P*; Sub: *P*, *S*	Agg: 15 kHz, Sub: 3 s
Sample	USA	7 days	10	12	*S*	1 min
Smart*	USA	3 months	1 Submeter, 2 Agg & Sub	25 circuits + 29 appliance	Circuits: *P*, *S*; Submeter: *P*	1 Hz
Tracebase	Germany	N/A	15	158	*P*	1–10 s
UK-DALE	UK	499 days	4	5–53	Agg: *P*; Sub: *P*, switch	Agg: 16 kHz, Sub: 6 s

Table 1. Existing energy datasets.

- House #1 an apartment with one floor in Klagenfurt (AT), whose residents are a young couple, spending most of daylight time at work during weekdays, mostly being at home in evenings and weekend. Monitored devices include a fridge, a dishwasher, a microwave, a water kettle, a washing machine, a radio with amplifier, a dryer, kitchenware (mixer and fruit juicer), and a bedside light.
- House #2 a detached house with two floors in Spittal an der Drau (AT), whose residents are a mature couple (one housewife and one employed) and an employed adult son (28 years). Monitored devices include TV, networked-attached storage (NAS), washing machine, drier, dishwasher, notebook, kitchenware, coffee machine, and bread machine.
- House #3 a detached house with two floors in Klagenfurt (AT), whose residents are a mature couple (one working part-time and one full time), living with two young kids. Monitored devices include entrance outlet, dishwasher, water kettle, fridge without freezer, washing machine, hair drier, computer, coffee machine, and TV.
- House #4 an apartment with two floors in Udine (IT), whose residents are a young couple, spending most of daylight time at work during weekdays, although being at home in evenings and weekend. Monitored devices include total outlets, total lights, kitchen TV, living room TV, fridge with freezer, electric oven, computer with scanner and printer, washing machine, and hood.

- House #5 a detached house with two floors in Colloredo di Prato (IT), whose residents are a mature couple (one housewife and one employed) and an employed adult son (30 years). Monitored devices include: plasma TV, lamp, toaster, stove, iron, computer with scanner and printer, LCD TV, washing machine and fridge with freezer.
- House #6 a terraced house with three floors in Udine, (IT), whose residents are a mature couple (one working part-time and one full time), living with two young children. Monitored devices include total ground and first floor (including lights and outlets, with white goods, air conditioner and TV), total garden and shelter, total third floor.
- House #7 a detached house with two floors in Basiliano (IT), whose residents are a retired couple, spending most of time at home. Monitored devices include TV with decoder, electric oven, dishwasher, hood, fridge with freezer, kitchen TV, ADSL modem, freezer, and laptop with scanner and printer.

The GREEND dataset is provided for free via the SourceForge page.[2] Possible applications of GREEND include the derivation of appliance usage patterns, occupancy detection and developing and testing load disaggregating algorithms.

3. Analyzing energy use and improving awareness

Energy efficiency can generally be improved by replacing loads with more efficient ones, improving building efficiency (e.g., using a better insulation for windows), as well as optimizing energy usage. For the latter, a possibility is to analyze energy data, collected by the growing number of digital meters, as in Beckel et al. [11].

This allows utilities to offer targeted services, based on derived information such as size, income and consumption patterns. Efficiency is very dependent on energy awareness. The main problem of common billing mechanisms is the delay occurring between energy consumption and feedback. Prepaid billing offers a way to mitigate this problem, being the balance commonly reported on the energy meter and disconnections occurring upon expenditure. This was shown by DEFG, leading to 11% savings in UK [12].

Interactive systems can be employed to monitor and display energy production and consumption information and assist decision making. The effectiveness of these solutions depends greatly on the sensitivity and motivation of served users [13]. Also, as identified by Erhard-Martinez et al. [14] and Armel et al. [15], most effective feedback mechanisms are those provided at time of consumption (i.e., direct) rather than as historical (i.e., indirect), especially when breaking down consumption and costs to the appliance level, as this leads to an average of 12% savings in the considered studies. In particular, [15] estimated a potential of up to 20% savings when feedback is enforced by tailored advice, that is, tips on how to improve consumption behavior as based on actual device availability and usage (see **Figure 1**).

[2]https://greend.sourceforge.net/.

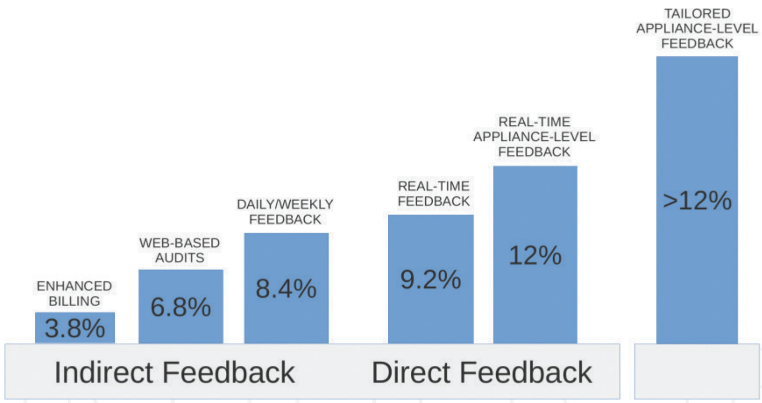

Figure 1. Effectiveness of existing feedback mechanisms [13].

In the study reported in Monacchi et al. [16], we analyzed the GREEND dataset to identify energy hogs and possible policies for improving overall efficiency, which can be summarized as:

- Promoting replacement of particularly consuming devices (e.g., incandescent light bulbs) with more efficient ones. This also has a diagnostics component, as device performance tends to change with aging.
- Promoting shedding of stand by devices, especially as resulting from consumer electronic devices (e.g., TV and modem). Occupancy models can be exploited to minimize user discomfort.
- Promoting device operation in off-peak time periods. This includes both deferral and preference of efficient devices over energy-demanding ones, such as using the LCD TV during the day and the plasma over the night period.
- Promoting device curtailment as consequence to anomalous behavior (e.g., with respect to the average number of usages).

While these policies can result from common sense and have a general validity, our intention was to provide an interactive system, able to autonomously analyze collected data to return most effective advices. In particular, this resulted in the design of an energy advisor, formulating advices over two steps: (i) candidate generation, in which advices are formulated depending on the availability of specific device types and ranked based on their saving potential, and (ii) information filtering, in which advices are ranked and filtered, as based on user's previous experience and responses. In particular, user's feedback to the advisor is explicit, with namely: "Ok thanks," "I am already doing it," "No thanks" (see **Figure 2**). A recommendation is considered converted in a behavior when the user explicitly accepts it as being already followed. Converted advices are directly deactivated. A usefulness score is instead computed for all others, as using the votes from positive (i.e., "Ok thanks") and negative (i.e., "No thanks") feedback. Consequently, positive feedback reinforces the advice by increasing its score, while negative feedback can result for a mistrust in the advice type

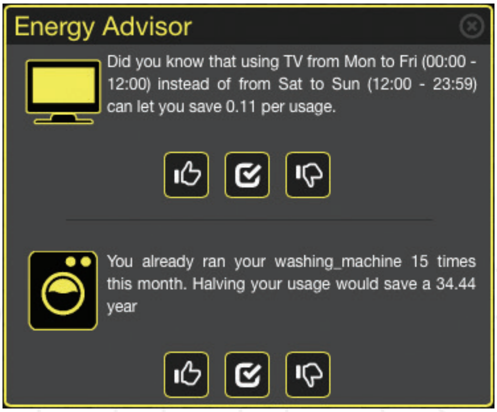

Figure 2. The energy advisor.

or the specific device category to be operated. As such, the system needs further specification and prompts the user with the selection of a cause. Based on this cause, the score of all advices of same type for the user or vice versa for the device category is decreased. The usefulness score is used to rank the advices, and randomness is introduced for those with same value.

The advisor was later implemented as a widget in the Mjölnir: an open-source energy management system, which we publicly released to the research community. Mjölnir provides a modular web-based dashboard where data analysis is implemented in the form of widgets, which can be arranged on the interface and reused on different data sources.

An estimation of potential savings yielded by the feedback mechanism followed the analysis, calculated in a potential of 34% using the sites measured in the GREEND dataset. The analysis was then concluded with a small usability and acceptance study, where seven participants engaged in a guided interaction with the widget, while we were interested on validating the effectiveness of the advisor widget in informing and persuading them.

The experimental setup consisted of a synthetic scenario, which included: a coffee machine, a washing machine, a dishwasher, a PlayStation 4 and a television. The attractiveness of the design was ultimately rated using a satisfaction questionnaire, where we used a five-point Likert scale, with "strongly agree" (+2) as a left anchor and "strongly disagree" as a right anchor (-2). Although limited, the analysis suggested that while the advisor can deliver "useful" and "tailored" information, it lacks on engaging users on a long term (i.e., after an initial learning curve). The results are reported in **Figure 3**. The nine questions included: "it takes short time to learn the meaning of the buttons," "the position of the buttons is logical," "I understand what happens when I click the buttons," "the advices are unusual, inventive, original," "the advices are useful to improve energy efficiency," "The advices are doable," "I can learn something from the advices," "I would use this widget every day" and "I would use this widget again."

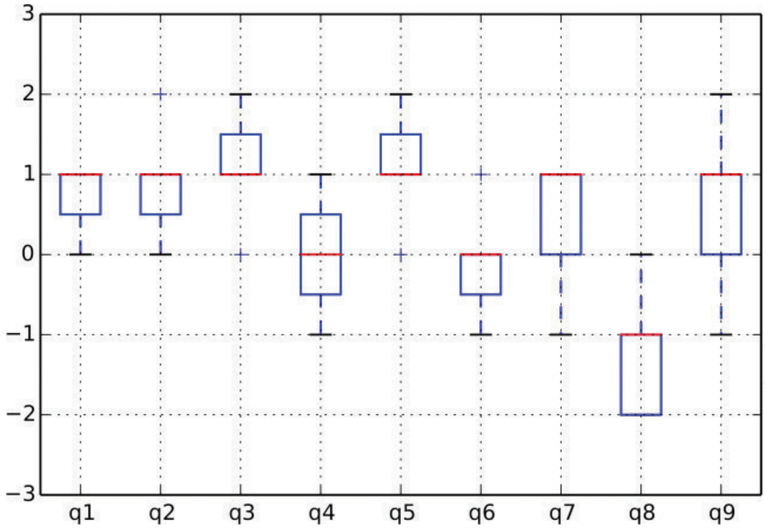

Figure 3. Early acceptance of the energy advisor.

4. Integrating renewable energy sources

Using renewable energy sources in a microgrid is a challenge, since typical renewable sources like PV or wind are dependent on meteorological conditions, which are themselves hard to predict. Therefore, one needs to address the problem of accurate prediction of renewable generation and based on these data find an optimum configuration for a smart microgrid. In the following, we give an example for a prediction approach for power generated by a PV systems, followed an optimization example for sizing the components of a smart microgrid.

4.1. Predicting solar radiation

When modeling renewable energy systems with unpredictable sources as solar or wind power, a more accurate prediction can be the key to their effective utilization. For example, being able to predict the expected minimum output over a duration of several days helps to find a minimum size of the battery storage of such a system, which means saving resources and money in their production. In other words, an accurate prediction of renewable energy sources can be the key to a sustainable development of energy systems.

However, predicting parameters related to weather phenomena can be very hard, given the complex nature of meteorological systems. For a PV system, for example, it is straightforward to depict the position of the sun at a given point in time, but other effects related to clouds, fog and reflections of sunlight are difficult to model and might require to adjust the model based on the climatic condition at the deployment site. In Ref. [17], an artificial neural networks (ANNs) is trained and used to make accurate predictions for a specific site. Therefore, parameters like current time and date, humidity, sunshine ratio, temperature and geographical

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parameters like latitude and longitude are used to make a prediction on direct and diffuse radiation. While this approach requires a history of previous radiation and weather measurements to learn the corresponding correlations, it allows a more accurate prediction of the solar radiation in comparison with predefined models. A schematic diagram of an ANN used for solar radiation prediction is illustrated in **Figure 4**. The network has three layers: the input, hidden and output layers. Each layer is interconnected by connection strengths, called weights.

4.2. Sizing microgrids

The introduction of photovoltaic-based distributed generation (DG) units in the distribution system may lead to several benefits such as voltage support, improved power quality, loss reduction, deferment of new or upgraded transmission and distribution infrastructure and improved utility system reliability. The installation of DG units at nonoptimal locations and with nonoptimal sizes may cause higher power loss, voltage fluctuation problem, system instability and amplification of operational cost.

Before installing DG units in a distribution system, a feasibility analysis has to be performed. DG owners are requested to present the type, size and location of their DG. The power system is usually affected by the installation of DG. Therefore, the allowable DG penetration level must comply with the harmonic limits. Thus, optimal placement and sizing of DG is important because installation of DG units at optimal places and with optimal sizes can provide

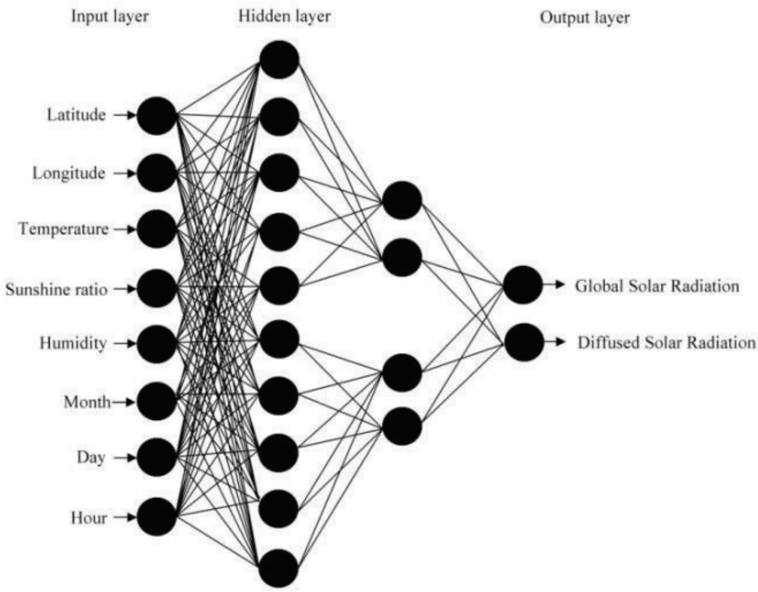

Figure 4. Topology of the GRNN used to model the global solar radiation.

economic, environmental and technical advantages such as power losses reduction, power quality enhancement, system stability, and lower operational cost.

The meta-heuristic method is also used in optimal placement and sizing of DG in distribution systems. This method applies an iterative generation process which can act as a lead for its subordinate heuristics to find the optimal or near-optimal solutions of the optimization problem. It combines different concepts derived from artificial intelligence to improve performance. Some of the techniques that adopt meta-heuristics concepts include genetic algorithm (GA), Tabu search, particle swarm optimization (PSO), ant colony optimization (ACO), and gravitational search algorithm (GSA).

The implementation of a general optimization technique for solving the optimal placement and sizing of DG problem is depicted in **Figure 5**. A multi-objective function is formulated to minimize the total losses, average total voltage harmonic distortion (THDv) and voltage deviation in a distribution system. The procedures for implementing the general optimization algorithm for determining optimal placement and sizing of DG are described as follows:

- Obtain the input network information such as bus, line and generator data.
- Randomly generate initial positions within feasible solution combination, such as the DG location; DG size in the range of 40–50% of the total connected loads; and DG controllable bus voltage in the range of 0.98–1.02 p.u.
- Improvise the optimization algorithm using the optimal parameters such as population size, number of dimension and maximum iteration.
- Run load flow and harmonic load flow to obtain the total power loss, average THDv and voltage deviation.
- Calculate the fitness function.
- Check the bus voltage magnitude and THDv constraints. If both exceed their limits, repeat step iv.
- Update the optimization parameters.
- Repeat the process until the stopping criterion is achieved and the best solution is obtained.

4.3. Simulating microgrids

Simulation is an efficient way to investigate various questions in research as well as in engineering. This holds also true for microgrids. The specifics in simulation of microgrids relate to size of the grid, the type of power generation and the particular questions to answer. Independently, the microgrid simulation is constituted of the models for the physical microgrid, the production facilities and the consumption patterns. All these models need to fit the required time resolution or, more general, the level of accuracy.

The model of the microgrid represents the physical properties of the grid. In the simplest form, it ensures that the power balance equation holds. More detailed models capture the

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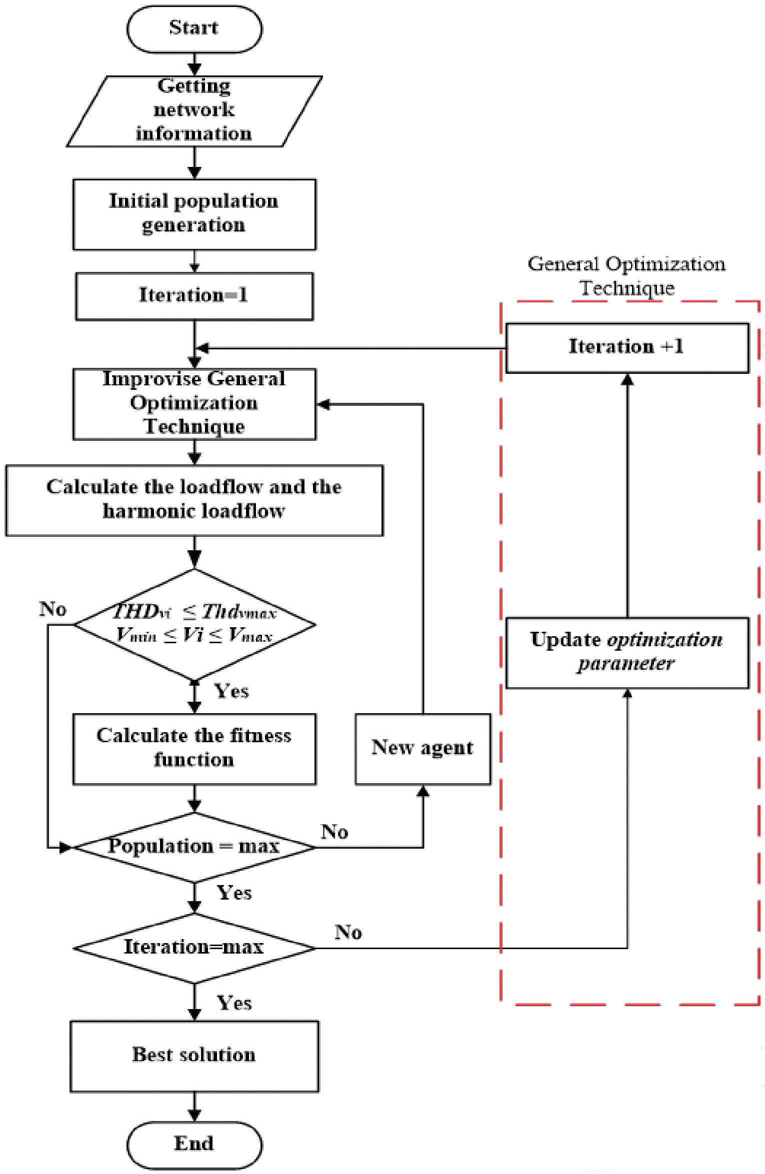

Figure 5. Flowchart of the general optimization technique for determining optimal placement and sizing of DG in a distribution system.

power flow on the different branches of the microgrid for each phase. Power flow simulation is a well-studied question and widely applied in (transmission) grid load schedule processes. Further parts of a microgrid model are a central controller and the circuit breaker which manage the connection to the superior grid.

Models for load profiles of consumers as well as generators vary a lot in their accuracy. In a widely used approach, measured values of similar real life utilities are used to as time series for simulation. This method is especially efficient when the power profile contains periodic patterns of different length, like daily, weekly or annual events which are hard to model. The recorded data must cover the full annual cycle (or duration of simulation) and cannot be arbitrary generalized. Such models are common for sizing of renewable energy production facilities, like PV and wind turbines, and for residential consumer loads. More sophisticated are physical models where the related processes are described with detailed mathematical equations. Successful examples are the production of a PV system under blue sky conditions as a function of time and date or the heating power of a house depending on the outside temperature. Other modeling techniques based on artificial neural networks or Markov processes require a big dataset to train the model. Those models are expected to handle stochastic events better than physical model, like cloud coverage of PV systems.

Consequently, a simulation platform for microgrids needs to provide physical grid simulation and a variety of models for power generation and consumption. The two historical fields power system simulation and renewables production forecasts, which developed separately, should be combined in microgrid simulation. In Ref. [18], several open-source simulators have been compared, where the different features and aims of the simulation systems become apparent. Some recent simulators such as GridLAB-D [19] or RAPSim [20] aim at integrating different features, especially by addressing renewable energy sources.

5. Automating energy management

As previously identified, demand response has been advocated as a potential solution to involve consumers into the stabilization of the power grid. In particular, demand-side management can be classified as (i) direct load control, namely with the utilities exploiting a direct communication channel to control their customers' appliances, and (ii) indirect load control where a price signal is shared to reflect the availability of energy resources (see [21] for a complete overview of demand response approaches). Indirect demand response assumes that users will timely react to system changes (i.e., price changes) and control their load. A higher degree of autonomy has to be achieved throughout the system to effectively introduce demand response. Hence, we discuss in this section on the possibility of designing controllers for energy prosumers.

5.1. Controlling energy prosumers

Energy management using computational agents has been addressed in previous work, such as [21–23]. In particular, coordination has been implemented using various mechanisms: cooperative games [24, 25], noncooperative games [23, 26–29], especially double-sided auctions [30–32]. Ideally, energy management is performed by finding a suitable operational schedule, with respect to a previously truthful revelation of agents' preferences. This demands an infrastructure sized to handle the centralized optimization of schedules, and it most importantly assumes the cooperative nature of agents, that is, they will reveal their schedule without having any interest in gaining power in the system. However, energy management is typically a process performed by decentralized entities, as such energy resources are, which pursue their own goal competitively. Electronic markets provide a framework to regulate the allocation of limited resources to competing agents [33]. Auctions use the shared price signal to assign resources to those agents that value them most, that is, that bid best. Coordination is in this case a process distributed across the community, meaning that no central optimizer takes care of computing the schedules and allows the agents for keeping their utility function private. Auctions can be classified in multiple ways, among which (i) single-sided and two-sided depending on the presence of both multiple buyers and sellers, and (ii) single-unit rather than multi-unit or combinatorial depending on the divisibility of the traded commodity. We forward the reader to [34] for a complete overview on auctions. Energy markets are commonly distinguished in (i) a wholesale market in which producers compete to supply energy to retailers and (ii) a retail market in which end customers select their provider. In our work, we advocate for achieving coordination using double-sided auctions. In this kind of markets, bid matching is a very lightweight process consisting in sorting all received ASK and BID offers for their price, so that the very best can result in a transaction. The so-called orderbook can be kept on a peer-elected agent, or distributed on each agent. This avoids any single point of failure in the architecture. In Monacchi et al. [35], we introduced the HEMS simulator (see **Figure 6**), which allows for simulating energy production and usage in microgrids, in order to learn controllers for energy prosumers. While other simulators exist in literature to model users' consumption behavior [36, 37], they lack in offering a complete solution for modeling consumption and production, as well as learning appropriate control strategies. To this end, we introduced a prosumer controller based on artificial neural networks (see **Figure 7**). The

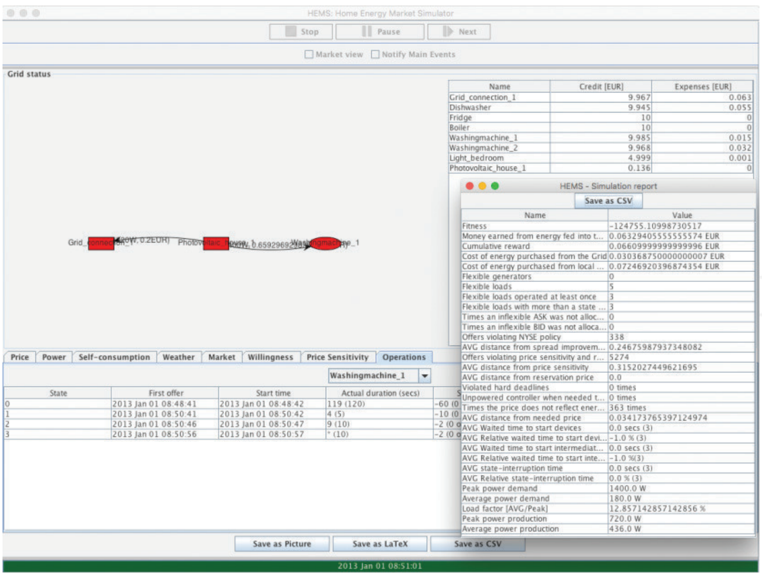

Figure 6. The HEMS simulator.

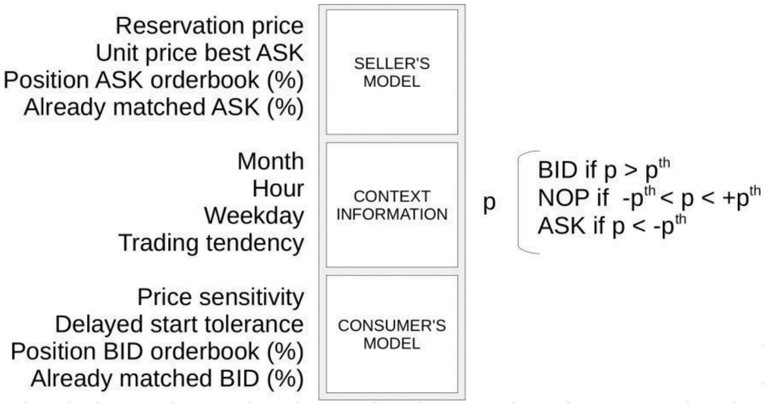

Figure 7. The introduced controller.

controller uses both a buyer and a seller model, along with contextual information to model time and trading tendency. Accordingly, a tendency value is computed to reflect the availability of local energy (i.e., as resulting from a battery element or local generation) which could be sold, or vice versa the necessity to buy energy if operation needs or was previously started. The latter value is taken directly as a probabilistic usage model embedded in the agent, which was previously extracted from an energy consumption dataset.

The controller can be trained using multiple methods. In the paper, we defined a cost function based on operational costs and user discomfort (i.e., delayed or interrupted operation) and showed the controller being successfully trained to trade power in a uniform-price double auction (UCDA), using the NNGA evolutionary algorithm. In particular, we selected in the study a 1-s allocation interval. Sizing such an interval depends directly on the state length of operated loads, as we desire on one hand to operate without service interruption, which a 15-min interval as in Ref. [30] can ensure, but on the other hand it is necessary to guarantee system responsiveness (i.e., a minimal delay between trading time and allocation time such that environment changes can be addressed). For this reason, any statically defined allocation size in a strictly competitive environment will always lead to suboptimal results, that is, service interruption. To address this problem, we investigated in Monacchi and Elmenreich [38] the design of an energy broker providing microgrids customers with the possibility to buy service-level agreements, namely power provisioning contracts having different duration, and consequently different price and uncertainty.

6. Conclusions

The proposed approaches contribute to sustainable growth at various stages of the design cycle. First, the collected data on energy consumption allow for an assessment of required electrical energy on a fine-grained time basis. This is necessary to avoid bulk assignments

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in energy planning that are usually based on a larger value when there is doubt about the expected energy consumption. Moreover, it allows pretesting systems via simulation before an actual deployment. A system for measuring energy consumption data furthermore enables feedback systems that inform consumers and involve them in decisions regarding device usage. This is a prerequisite for efficiently using renewable energy sources, since without some flexibility in device usage and, therefore, energy demand, excess energy from renewables eventually goes back into the grid or needs to be stored. Storage is comparably expensive, and feed-in tariffs are expected to further drop, which on the one hand is an economical problem for the owner of the production system and on the other hand poses a problem for the overall grid, when energy production exceeds demand due to renewable energy production peaks. Current solutions such as a reduction or cap of production mean letting green energy production units underused. The proposed automatic control of energy consumers based on machine-learned intelligence further develops the idea of a self-organizing and self-balancing energy management system, which relieves the users from micro-managing their appliances according to the current microgrid situation.

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Assessing the Possible Potential in Energy Consumption and Greenhouse Gas Emission: Application of a Proven Hybrid Method

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Abstract

Energy evaluation together with greenhouse gas mitigation goes a long way in sustaining the growth and economy of a nation. Various evaluation methods have been adopted by researchers, academia and various country wise energy department ministries to achieve this aim. The most effective method is the hybrid evaluation method. This takes into consideration strength of a particular method to overcome the weakness of another method. This chapter focuses on a recently proven integrated method on energy and greenhouse gas studies—integrated IDA-ANN-DEA (index decomposition analysis—artificial neural network—data envelopment analysis). Case studies were exemplified using this approach in evaluating possible energy potential that could be saved in the manufacturing industries in Canada and South Africa as well as a particular food and beverage industry. Another case study focused on the amount of possible greenhouse gas that could be mitigated in the Canadian industry. The hybrid model proved very useful in its analysis.

Keywords: energy, evaluation, greenhouse gas, mitigation, hybrid method, IDA-ANN-DEA

Overview

Energy's involvement in the growth of the economy is very crucial. The role it plays, as well as greenhouse gas, has led to various questions leading to various practices and trends in research and development (R&D). One of the leading objectives of R&D in the energy sector is to find how best to conserve energy. To achieve this objective, research trends in energy use, energy potentials, policy formulations as well as investment patterns and technology choices have been ongoing.

1. Introduction

A huge amount of potential exists which is yet to be tapped for energy efficiency in all sectors that improves the economy [1]. From [2] definition 'evaluation is a careful retrospective assessment of merit, worth, and value of administration, output and outcome of governmental interventions, which is intended to play a role in future, practical situations'. Various tools are used to identify opportunities that lie in energy efficiencies as well as energy-saving potentials. Energy evaluation goes a long way by affording users where improvement is needed. On the other hand, it also saves money on a long-term basis. During energy evaluation, lots can be achieved from revelation of the way energy is consumed, waste identification to efficient use of energy. Not only is energy efficiency being introduced when energy use is successfully evaluated but also during greenhouse gas evaluation, as it is well known that the struggle against environmental pollution has been for a decade plus [3].

Efficient energy use continues to be a significant topic both nationally and internationally when policies are discussed. It remained one of the fundamental areas for sustainable growth environmentally and economically [4, 5]. The evaluation of energy efficiency in various countries has been significant to each of the countries. Various quantitative methods have gained popularity with various researchers and scholars in this regard [6]. Not too long was an agreement made by the European Union (EU) that at least a saving of 27% of energy should be realized between 2020 and 2030 when compared with the business-as-usual and various policy objectives [5, 7]. Among the methods employed is the economic analysis that considers engineering assumptions and benchmark factors as well as methodological techniques [6]. Other methods are the hybrid models. Models have been agreed by the scientific world to be a scientific standard tool applied to various indicative factors on a comprehensive note [6].

The consumption of energy mostly gives room for pervasive externalities, ranging from local to global emissions which do not reflect in costs of energy supply as well as the preparation efforts [8]. Most recently, the issue of GHG emissions has attracted serious attention that it has given rise to global research in the climate change arena [9]. With unmitigated GHGs, there will be continuous adverse effects in the global environment [10]. The reduction of GHG is known to be the key mitigation process in combating climate change [11]. However, knowing the amount of possible emission that would be reduced goes a long way. Addressing climate change issues as well as establishing targets of GHGs that need reduction from industrialized/developed countries was recognized during the conference of parties (COP) which took place in Kyoto, Japan, in 1997 [12]. Subsequent COPs after that continued to recognize this need to address climate change issues.

Studies have confirmed that both commercial and domestic buildings constitute up to 33% of the GHGs emitted in the global village [13]. Emission of GHGs has proved to be a key threat that can lead the world human civilization's collapse in the present century [14]. It is crucial to reduce the amount of GHGs that are being emitted to the atmosphere [15]. Modelling has gained upperhand in supporting most decisions made which can help develop and introduce fresh management practices to see to the reduction of GHGs [16]. From 1990 to 2010, the global economic growth grew to 88% [17], leading to 45% energy-related CO_2 emission increase [18]. As informed by the study of Ref. [19], 'One of the most important issues in the policy debate is

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the role to be played by developing countries for reducing GHG emissions, and particularly CO_2 emissions side by side with developed countries'. A very practical and rigorous effort will always be needed in mitigating climate change [20].

Appropriate methodologies do help in implementing appropriate mitigation approaches in the areas of GHGs as well as conservation techniques in the areas of energy consumption. An integrated approach has been advocated for solving the energy/greenhouse gas problems [12]. The objective of this chapter is to understand the application of a particular hybrid methodology (IDA-ANN-DEA) in the assessment of energy-saving potential and GHG mitigation potential. The continuous increase in the amount of energy consumed and the GHGs emitted necessitated the development of this hybrid model.

2. Hybrid methods

Most recent methods adopted to evaluating energy studies are the optimization models. These optimization models can be grouped into three algorithms according to Ref. [21]; these are evolutionary, derivative-free search and the hybrid algorithms. Evolutionary methods include genetic algorithms (GAs) and its improved states like non-dominated sorting genetic algorithm II (NSGA-II) among the rest, particle swarm optimization (PSO) and other evolutionary methods [22]. Derivative-free search are the direct search methods [23] like Hooke-Jeeves, coordinate search and mesh adaptive search, among others. The hybrid is an integration of various methods [22]. One of the combined methods often times serves to offset the bias of the other. Taking nothing from the other two methods, they are very unique and efficient in their own way when it comes to evaluating energy use; however, this study focuses on the hybrid method which combines the strength of each model into a single capacity. Among the hybrid studies relevant to energy evaluation are the studies of Refs. [24–27].

From the study of Ref. [26], they showed how the hybrid of GA with simulated annealing (SA) optimized successfully a thermal building. The technique was employed under various climate conditions. The results generated from the approach were much more reliable when compared to employing either GA or SA alone. In another study of analysing energy performance of a building [25], it compared two different hybrid methods. These are hybrid covariance matrix adaptation evolution strategy algorithm and hybrid differential evolution (CMA-ES/HDE) and the second is PSO/HJ. In their study, CMA-ES/HDE performed successfully on complex objective functions whereas PSO/HJ identified the objective functions optimally. In comparison of these hybrid models, CMA-ES/HDE performed better with less parameters, however, PSO/HJ performed better when problem dimension increased. However, this study focuses on the IDA-ANN-DEA hybrid method.

3. IDA-ANN-DEA

This chapter employed the hybrid index decomposition analysis (IDA), artificial neural network (ANN) and data envelopment analysis (DEA) as an evaluation model to determine the way energy is consumed and how greenhouse gas could be mitigated through identification of waste and how best to use/mitigate energy/greenhouse gas efficiently. This will best identify the possible potentials that could be saved and how much greenhouse gas is possibly awaiting mitigation. From the structure of the hybrid model in **Figure 1**, regression analysis played a vital role in verifying and validating ANN in this hybrid approach. The mathematics behind this model will be elaborated.

The structure of the framework presented below indicates independent inputs depending on the amount of inputs; however, for this study, input activity, structure, intensity and energy mix (for greenhouse gas) are the most common inputs responsible for energy consumption and greenhouse gas, and the output in this situation is always the energy consumed/greenhouse gas emitted. As the structural framework shows, the output is being decomposed through logarithmic mean Divisia index (LMDI) to the various independent variables. LMDI is one of the most used IDA. The energy consumption/greenhouse gas is predicted to decide the reference energy consumed/greenhouse gas emitted by employing the input factors to the ANN. Through validation of the reference energy outcome, this allows the DEA to execute its sensitivity analysis using both the actual and predicted energy/greenhouse gas to decide how much possible energy/greenhouse gas potential could be saved/yet to be mitigated (**Figure 2**).

The steps to applying the model are given below:

(I) LMDI based on IDA performs the operation for the assessment of the various GHG and energy consumption drivers.

(II) Total inputs and outputs are selected for the ANN prediction process.

(III) The predicted results of ANN are verified and validated by the result of regression analysis.

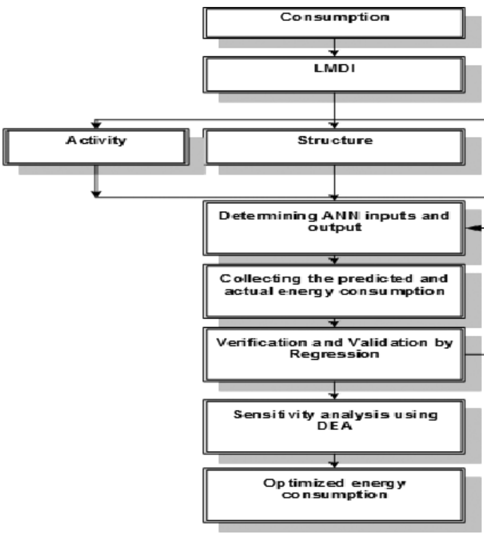

Figure 1. Hybrid structure for energy potential analysis.

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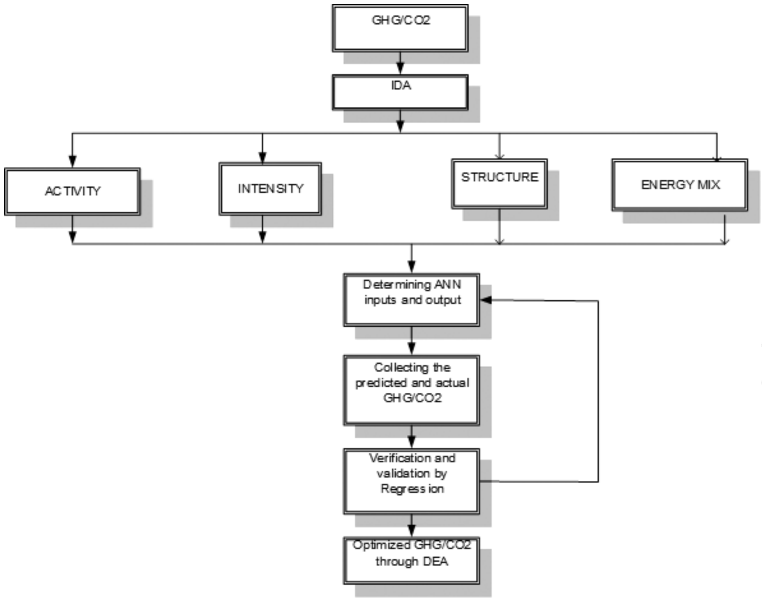

Figure 2. Hybrid structure for greenhouse gas potential analysis.

(IV) DEA sub-model is applied to determine the efficient computation for CO_2 emission/energy consumption that can be obtained.

The equations governing the analysis of energy consumption and greenhouse gas potentials towards the hybrid models are given below:

E_i: sector's aggregated energy consumed

E: aggregated energy consumed $\left(E = \sum_i E_i\right)$

Q_i: sector's production value

Q: aggregated production value $\left(Q = \sum_i Q_i\right)$

S_i: sector's production share $\left(S_i = \frac{Q_i}{Q}\right)$

I_i: sector's intensity of energy consumed $\left(I_i = \frac{E_i}{Q_i}\right)$ and $\left(w_i = \frac{(E_i^T - E_i^0)/(\ln E_i^T - \ln E_i^0)}{(E^T - E^0)/(\ln E^T - \ln E^0)}\right)$

D_{act} denotes activity, D_{str} denotes structure and D_{int} denotes intensity.

$$D_{\text{act}} = \exp\left[\sum_i w_i \ln\left[\frac{Q_i^T}{Q_i^0}\right]\right] \tag{1}$$

$$D_{\text{str}} = \exp\left[\sum_i w_i \ln\left[\frac{S_i^T}{S_i^0}\right]\right] \tag{2}$$

$$D_{\text{int}} = \exp\left[\sum_i w_i \ln\left[\frac{I_i^T}{I_i^0}\right]\right] \tag{3}$$

$$U_{\text{tot}} = D_{\text{act}} + D_{\text{str}} + D_{\text{int}} \tag{4}$$

For greenhouse gas potential analysis, the following applies:

C: total CO_2 emission

C_{ij}: CO_2 emissions arising from fuel j in industrial sector i

E_{ij}: consumption of fuel j in industrial sector i, where $E_i = \sum_j E_{ij}$

$M_{ij} = E_{ij}/E_j$: the fuel-mix variable

Q_i: value of production in sector i

Q: total value of production $\left(Q = \sum_i Q_i\right)$

S_i: production share of sector $i \left(S_i = \frac{Q_i}{Q}\right)$

I_i: intensity of energy consumption in sector $\left(I_i = \frac{E_i}{Q_i}\right)$

$$C = \sum_{ij} Q \frac{Q_i}{Q} \frac{E_i}{Q_i} \frac{E_{ij}}{E_i} \frac{C_{ij}}{E_{ij}} = \sum_{ij} Q S_i I_i M_{ij} \tag{5}$$

$$\frac{C^T}{C^0} = D_{\text{tot}} = D_{\text{act}} D_{\text{str}} D_{\text{int}} D_{\text{mix}} \tag{6}$$

where D_{tot} is the total CO_2 emission, D_{act} is the activity, D_{str} is the structure, D_{int} is the intensity and D_{mix} is the sectoral energy mix.

$$D_{\text{act}} = \exp\left(\sum_{ij} \frac{(c_{ij}^T - c_{ij}^0)/(\ln c_{ij}^T - \ln c_{ij}^0)}{(c^T - c^0)/(\ln c^T - \ln c^0)} \ln\left(\frac{Q^T}{Q^0}\right)\right) \tag{7}$$

$$D_{\text{str}} = \exp\left(\sum_{ij} \frac{(c_{ij}^T - c_{ij}^0)/(\ln c_{ij}^T - \ln c_{ij}^0)}{(c^T - c^0)/(\ln c^T - \ln c^0)} \ln\left(\frac{S_i^T}{S_i^0}\right)\right) \tag{8}$$

$$D_{\text{int}} = \exp\left(\sum_{ij} \frac{(c_{ij}^T - c_{ij}^0)/(\ln c_{ij}^T - \ln c_{ij}^0)}{(c^T - c^0)/(\ln c^T - \ln c^0)} \ln\left(\frac{I^T}{I^0}\right)\right) \tag{9}$$

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$$D_{\text{mix}} = \exp\left(\sum\nolimits_{ij} \frac{(c_{ij}^T - c_{ij}^0)/(\ln c_{ij}^T - \ln c_{ij}^0)}{(c^T - c^0)/(\ln c^T - \ln c^0)} \ln\left(\frac{M_{ij}^T}{M_{ij}^0}\right)\right) \tag{10}$$

$$D_{\text{tot}} = D_{\text{act}} D_{\text{str}} D_{\text{int}} D_{\text{mix}} \tag{11}$$

The multiplicative decomposition variables serve as input to ANN, whose equation is given by

$$y_j = f\left(\sum\nolimits_i w_{ij} x_{ij}\right) \tag{12}$$

Substituting the outcomes of Eqs. (1)–(3) (from energy consumption) and Eqs. (7)–(10) separately as input values and Eqs. (10) and (11) separately as the output value into Eq. (12), it becomes

$$U_{\text{tot}} = f\left(\sum\nolimits_i w_{ij} \left\{D_{\text{act}(ij)}, D_{\text{str}(ij)}, D_{\text{int}(ij)}, D_{\text{mix}(ij),}\right\}\right) \tag{13}$$

The goal is to minimize the average sum of the errors between the energy consumed and decomposed total CO_2 (output to the neural network) and the target energy consumed/total CO_2 (predicted energy consumed/CO_2). Thus,

$$mse = \frac{1}{Q}\sum\nolimits_{K=1}^{Q} \left[U_{\text{tot}} t(k) - U_{\text{tot}} a(k)\right]^2 \tag{14}$$

Where $U_{\text{tot}} t$ is the predicted energy consumed/total CO_2 and $U_{\text{tot}} a$ is the actual energy consumed/decomposed total CO_2.

From the DEA, interested readers can refer to [28]; substituting $U_{\text{tot}}(t)$ as the output variable and $U_{\text{tot}}(a)$ as the input variable, it gives

$$\begin{aligned} &\text{Max} \frac{\sum_{r=1}^{s} U_{\text{tot}}(t)_{ro} u_r}{\sum_{i=1}^{m} U_{\text{tot}}(a)_{io} v_i} \\ &\text{such that} \frac{\sum_{r=1}^{s} U_{\text{tot}}(t)_{ro} u_r}{\sum_{i=1}^{m} U_{\text{tot}}(a)_{io} v_i} \leq 1, j \ldots n \\ &v_i \geq 0, i = 1, \ldots, m; \\ &u_r \geq 0, r = 1, \ldots, s. \end{aligned} \tag{15}$$

With $U_{\text{tot}}(t)_{ro}, r = 1, \ldots, s$ representing outputs and the $U_{\text{tot}}(a)_{io}, i = 1, \ldots, m,$ representing inputs for each of $j = 1, \ldots, n,$ DMUs and $j = 0$ identifies DMUj to be evaluated. μ_r is the output weight while v_i is the input weight. Eq. (15) is thus transformed into an ordinary linear programming problem; $\mu_r = \beta\mu_r, v_i = \beta v_i$ is obtained with the same optimum value as Eq. (15)

$$\begin{aligned}
&\text{Max } \phi = \sum_{r=1}^{s} \mu_r U_{\text{tot}}(t)_{ro} \\
&\text{such that } \sum_{i=1}^{m} v_i U_{\text{tot}}(a)_{io} = 1, \\
&-\sum_{i=1}^{m} U_{\text{tot}}(a)_{ij} + \sum_{r=1}^{s} \mu_r U_{\text{tot}}(t)_{rj} \le 0, j = 1, \ldots, n, \\
&v_i \ge 0, i = 1, \ldots, m, \\
&\mu_r \ge 0, r = 1, \ldots, s.
\end{aligned} \tag{16}$$

Eq. (12) has a dual form that can be written as

$$\begin{aligned}
&\text{Min } \eta_o \\
&\text{such that } \sum_{j=1}^{n} U_{\text{tot}}(a)_{ij} \lambda_i \le U_{\text{tot}}(a)_{io} \eta_o, i = 1, \ldots, m \\
&\sum_{j=1}^{n} U_{\text{tot}}(t)_{ij} \lambda_j \ge U_{\text{tot}}(t)_{ro}, r = 1, \ldots, s \\
&\lambda_j \ge 0, j = 1, \ldots, n
\end{aligned} \tag{17}$$

Eqs. (16) and (17) will allow the accountability for the potential energy consumption and CO_2 emission while keeping the expected energy consumed and CO_2 emission at the baseline level.

4. Examples of applications of IDA-ANN-DEA

Case study 1: Application of the hybrid methodology in assessing possible GHG potentials for mitigation in the Canadian Industry

Objective: To determine possible potential for mitigation from 1991 to 2035 [29].

The study extended the decomposed factors responsible for the GHG emission from years 1991 through 2000 to 2035 results using least square trend line approach. This case study considered CO_2 based on final energy consumed without the report of induced electricity production. The considered fuels are coal, coke, coke oven gas, petroleum coke, natural gas, heavy fuel oil, LPG/propane as well as waste fuels consumption. Only 52 sectors and subsectors together with mining and all manufacturing industries with the omission of oil and gas extraction, forestry and construction industries were included.

The average decomposition result is given in **Table 1**. From **Table 1**, it showed that activity had the highest amount. From the second step of the application, the selected inputs were used to predict the output using the ANN. The ANN gave a good prediction with 4-6-1 structure. The average ANN results are depicted on **Table 2**. The results obtained were only accepted after successful validation through the regression analysis. The overall coefficient of correlation was

0.97 which proved to be a successful prediction. **Figure 3** shows the visual inspection to also validate the good prediction. Incorporating the ANN results into the DEA equation simulated gave the average efficient result in **Table 3**. The result singled out the year 1992 to be the best performing year that other years are to emulate. With the model implemented, it was discovered that 3.13% of GHG could be eliminated. The amount relates to the possible percentage potential of CO_2 that can be easily mitigated if the rest of the years were to emulate 1992 operations. **Figure 4** shows the graph for the amount of GHG that can be mitigated for each year considered in the study.

Year	Average CO_2	Average energy mix	Average intensity	Average structure	Average activity
1991-2035	0.959	0.994	0.915	0.886	1.202

Table 1. Average decomposition results.

Year	Average actual CO_2	Average predicted CO_2	Average error
1991-2035	0.959	0.96	0

Table 2. Average ANN results.

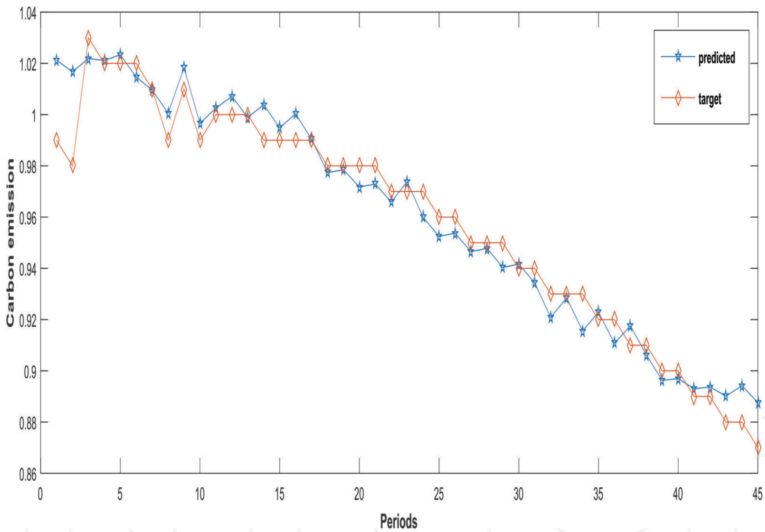

Figure 3. Visual inspection from the predicted and actual CO_2 emission [29].

Year	Average efficiency
1991-2035	0.969

Table 3. Average efficiency results.

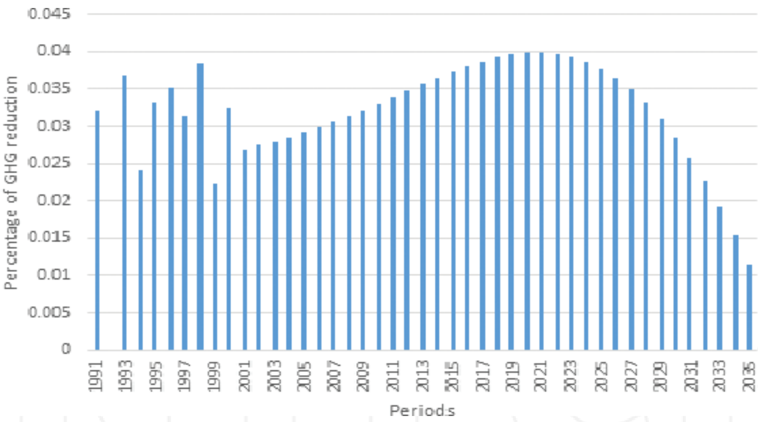

Figure 4. Amount of GHG potential that can be mitigated for the period of study [29].

Case study 2: Application of the hybrid methodology in assessing energy potential in a food and beverage industry in South Africa

Objective: To assess the effectiveness of energy management policies in a food and beverage industry [30].

Energy consumed in the production of two different products was analysed to determine how much energy potential to the food and beverage industry could have been saved between January 2010 and April 2012. The study employed both additive and multiplicative LMDI. The reason for the additive was to comprehend the way the various factors contributed to the amount of energy consumed while the multiplicative was for the integration into DEA as DEA was applicable for non-negativity results obtained from the multiplicative LMDI. **Table 4** shows the summary of the factors responsible for the energy consumed. During the period of study, it can be said that considering only the activity factor, total energy would decline by 11116.6 GJ, total structure by 83.58 GJ and intensity increased by 11644 GJ. This result in summary only indicated poor energy management.

Integrating the LMDI result into the ANN gave a good prediction with a structure of 3-5-1, three representing the activity, structure and intensity inputs, five representing the number of hidden neurons and one representing the energy consumption. **Figure 5** depicts the visual inspection of the prediction result. The regression also confirmed the successful prediction

	Possible energy (GJ)		
Period of study	**Activity**	**Structure**	**Intensity**
January 2011-April 2012	−11116.6419	−83.5841	11644

Table 4. Summary of factors responsible for energy consumed in a food and beverage industry.

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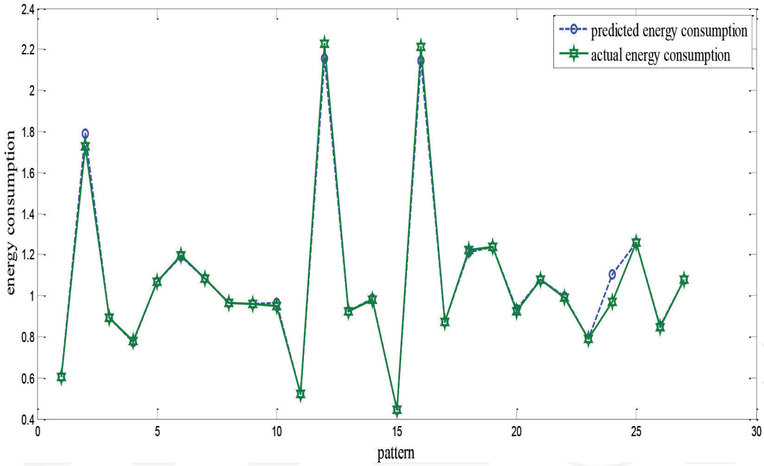

Figure 5. Visual inspection of actual and predicted energy consumption in the food and beverage industry [30].

with the coefficient of correlation result as 0.996. Integrating ANN result to the DEA equation singled out December 2011–January 2012 to be the most efficient month when energy was consumed. **Table 5** shows the average of all the efficiencies computed. If activities considered during this efficient month were to be considered throughout the period of study, the food and beverage industry would have saved 11% energy potential which is equivalent to 171, 533.78 GJ. **Figure 6** below shows the possible energy potential that could have been saved for each month.

Case study 3: Application of the hybrid methodology in assessing energy potential in the Canadian industry

Objective: To assess the energy efficiency through optimization of the responsible factors [31].

The consumption of energy within 15 aggregated sectors was successfully analysed by applying the hybrid methodology in the Canadian industry between 1990 and 2010. The industries included in the analysis were metal mining, non-metal mining, food industry, beverage industry, rubber products, plastic products, clothing industry, wood, furniture and fixtures, paper and allied products, printing public plus allied and primary metal. IDA decomposed the responsible factors to the energy consumed into activity, structure and intensity based on the provided data of production and energy consumption. **Table 6** shows the average of the decomposition results. The result clearly identified activity as the most important factor with intensity and structure having a close margin.

Period	Average efficiency
January 2010-April 2012	0.885

Table 5. Average efficiency result.

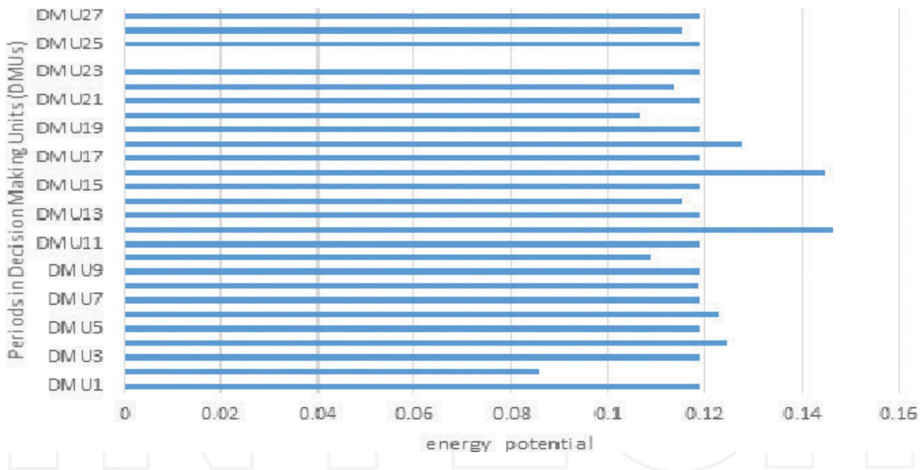

Figure 6. Possible energy potential [30].

Average energy consumption	Activity	Structure	Intensity
1.01856	1.01629	1.00086	1.00177

Table 6. Average decomposition result.

Integrating the outcomes of LMDI into the ANN equation gave an architectural structure of 3-6-1, where the 3 represents the decomposed inputs, 6 stands for hidden neurons and the 1 stands for the energy consumption as the output. **Table 7** shows the average ANN results while **Figure 7** shows the visual inspection result. The results validated the good prediction including the coefficient of correlation result which is 0.95. The integration of the ANN result to the DEA reported year 1994–1995 as the most efficient DMU, while year 1994–1995 was the least efficient of the DMUs. Comparing the efficient period to other periods in evaluating the amount of possible potential resulted into 0.47% of energy that could have been saved. **Table 8** shows the average efficiency obtained throughout the analysis and **Figure 8** shows the potential energy graph.

Case study 4: Application of the hybrid methodology in assessing energy potential in the South African industry

Objective: To assess the energy efficiency through optimization of the responsible factors [32].

The study successfully assessed the energy consumed in a cumulative of 11 sectors in the coal mining, other mining, basic iron and steel, non-metallic minerals, food, paper and paper

Year	Average actual energy consumption	Average predicted energy consumption	Average error
1990-2010	1.01856	1.0179	0.00066

Table 7. Average ANN results.

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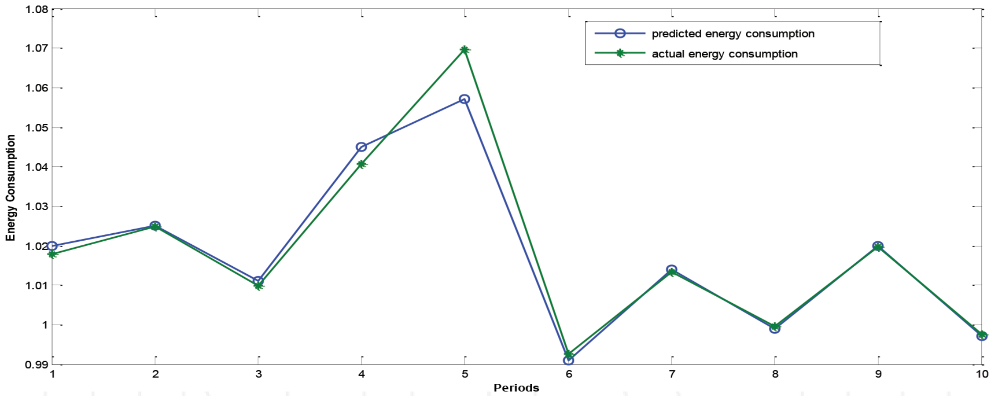

Figure 7. Visual inspection of actual and predicted energy consumption in the Canadian industry.

Period	Average efficiency
1990-2010	0.99529

Table 8. Average efficiency result.

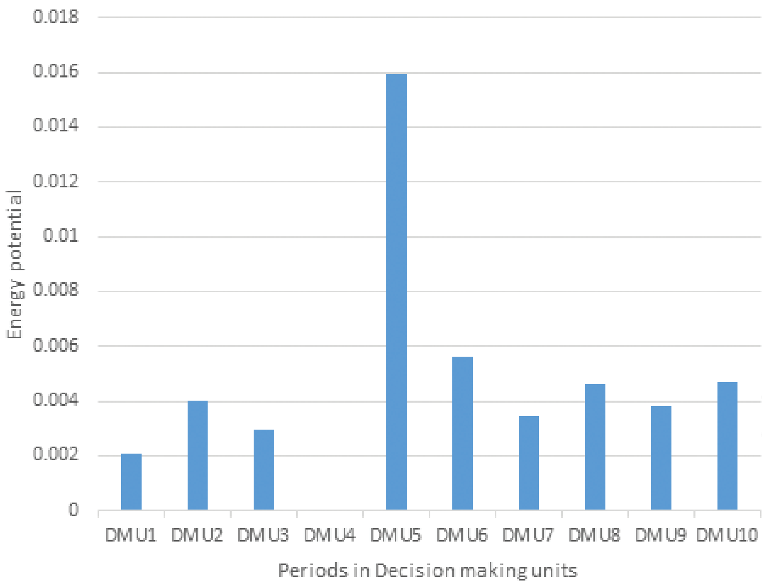

Figure 8. Possible energy potential.

products, gold and uranium ore mining, basic non-ferrous metals, basic chemicals, tobacco and other manufacturing items. These sectors are from the South African industrial sectors from 1971 to 2008. Most of the industries considered are high-energy intensive industries. The application of LMDI proved activity to be the most consistent factor as compared to intensity and structural factors. Activity contributed 36.53% to the energy consumed while intensity and structure contributed an almost equal amount in 31.74 and 31.73 %, respectively. **Figure 9** depicts the decomposed effects of the energy consumed.

Integrating the result from LMDI to ANN gave a successful prediction with 3 inputs, 4 hidden neurons and 1 that stands for energy consumption as the output in a 3-4-1 architectural structure. Validation of the result gave a coefficient of correlation of 0.99 together with a visual inspection in **Figure 10**. The integration of ANN results into the DEA equation and confirmed period 1975–1976 as the most efficient DMU period. The average efficiency is 0.55 which indicates a very poor run of energy efficiency. **Table 9** shows the average efficiency achieved within the period of study. Emulating the practices within year 1975–1976 could save the cumulative of 11 sectors 44.9% of potential energy. Compared to a developed country like Canada [31], a developing country like South Africa still has a long way to go. **Figure 11** shows the possible energy potential that could have been saved per inefficient DMUs.

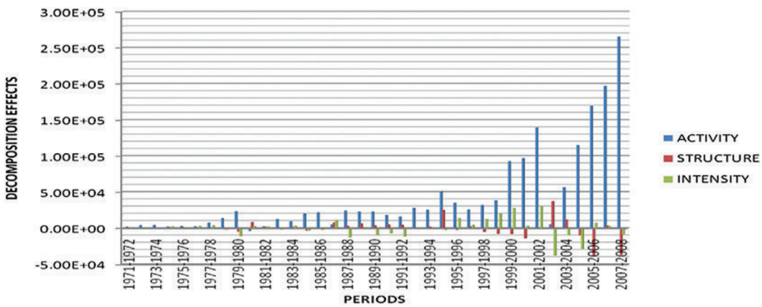

Figure 9. Decomposed effects to the energy consumed [32].

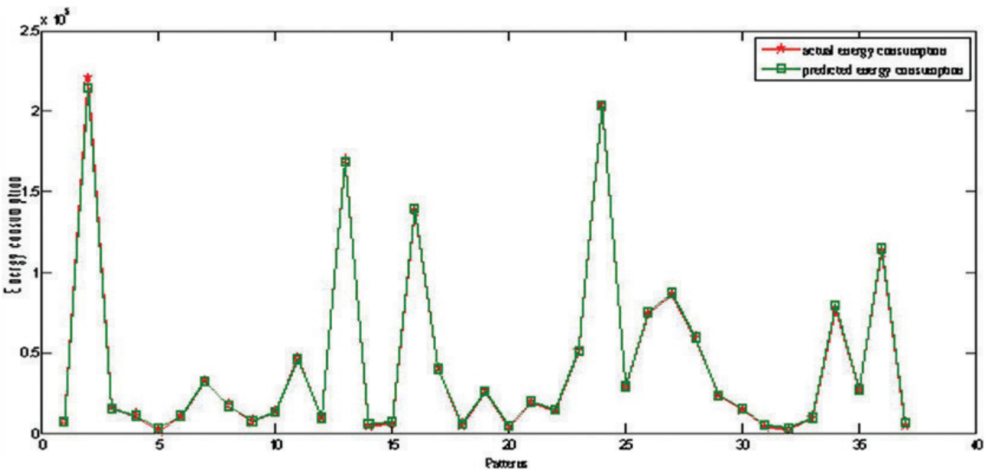

Figure 10. Visual inspection to the ANN prediction [32].

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Period	Average efficiency
1971-2008	0.55

Table 9. Average efficiency.

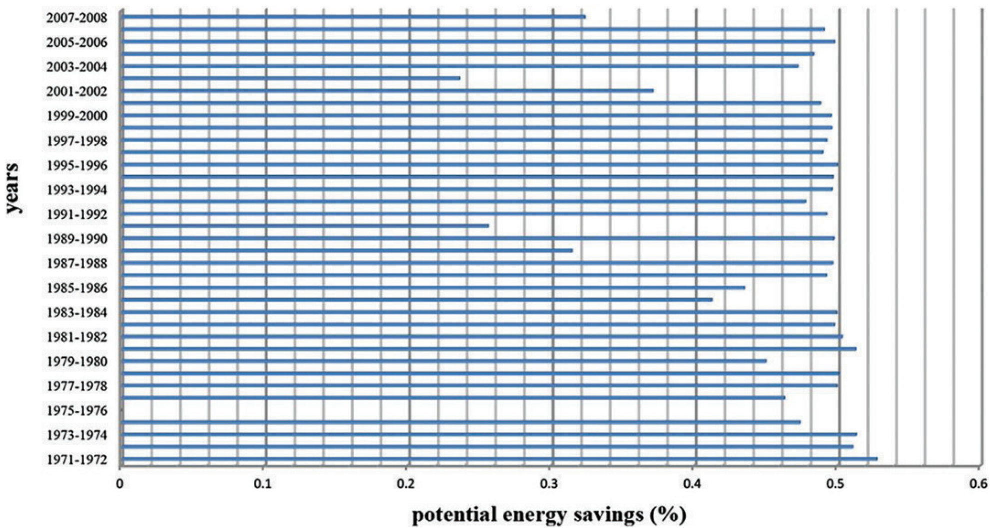

Figure 11. Possible energy-saving potential.

5. Conclusion

The hybrid method highlights the amount of energy that could be saved from the various case studies and possible greenhouse gas potential reductions observed in this chapter. Successful evaluation of energy use and mitigation of greenhouse gas with the hybrid method gives insight into how energy/greenhouse gas is being consumed and emitted in the industries of study, with similarity to other industries. Various hybrid methods exist to solving one problem or the other; this chapter however focused on a hybrid method with the advantage of offsetting the bias exhibited by one of the methods, with the strength of one method making up for the weakness of another method. This chapter expressed the various mathematics behind the models and their integration into a single model. The LMDI form of decomposition disintegrates both energy and greenhouse gas into the various factors that lead to the energy/greenhouse gas consumption/emission. The integration of the decomposed result must be a non-negative value for the hybrid model to be a success. Neural network has proved beyond reasonable doubt as a better prediction tool compared to traditional methods like regression analysis. However, regression analysis validated the perfection that neural network brings into the hybrid model. A proven benchmarking tool is the data envelopment analysis, which is the last method integrated into the hybrid model. It successfully identified the most efficient units and compared the efficient unit to the non-efficient to determine how best to make the non-efficient as efficient.

The hybrid model has energy, greenhouse gas, economy and environment combined to have a sustainable way of conserving energy/mitigating greenhouse gas and eliminating waste. From the case studies summarized, results proved energy planners can be easily assisted for a future green environment through the hybrid application. This can also assist in the formation of strategies and conservation schemes which can bring about relevant technology development as well as policies.

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Chapter 6

Research and Devolopment about Metallurgical Industry of Romania

Adrian Ioana, Augustin Semenescu and Mihnea Costoiu

Additional information is available at the end of the chapter

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Abstract

Our chapter wishes to be a critical and reasoned radiography of the evolution/involution of metallurgical industry in Romania during the period 1990–2016. The importance of metallurgical industry, for any state, is obvious and overwhelming. In this context, paraphrasing a known dictum, we can strongly say that in the industrial environment and in life generally 'if there is no metallurgy, nothing is!' The structure and content of our material is logical one and evolutionary. So, we firstly present in order a description of the main metallurgical companies in Romania (companies in the steelmaking industry: COS Mechel Targoviste, ArcelorMittal Galati; companies from non-ferrous metallurgy: Alro Slatina, CupruMin Abrud; metallurgical companies in the manufacturing and assembly industry: Metalurgica Aiud, Timken S.A Ploiesti). In Section 3, we describe critical components concerning the involution of steel industry in Romania. Thus, we analyse: benchmarks, restructuring of the steel industry in Romania, the impact of the global crisis on the steel sector in Romania, privatization, modernization/restructuring and monitoring between 2004 and 2008. In Section 4, we present the prospects of metallurgical industry in Romania, and in Section 5, we present technical-economic components specific to the industry of metal materials.

Keywords: metallurgical industry, research, development, restructuring, privatization

1. Introduction

Metallurgy is a branch of industry which includes the processes for obtaining metals from ores and from other raw materials and resources. Metallurgy includes the processing of ores, extraction of metals from ores, refining of metals, production of metal alloys, metal processing under pressure, manufacture of cast metal parts, thermal, thermochemical, thermomechanical processing, welding and soldering metals and alloys, surface coating of the metal parts with a layer of other metals by diffusion of certain substances (metallic or non-metallic) in the superficial layer of metal objects [1–3].

Metallurgy has existed since ancient times. The evolution and technological progress of metallurgy have generated and secured the general progress of humanity. Paraphrasing a known adage, ‘if there is no metallurgy, nothing is!’

Global steel industry is facing an overcapacity in production of over 700 million t, and the government of the states which produce steel is looking for solutions to keep the companies and their employees under the circumstances in which the consumption is declining [5–8].

Also, the dumping price to which is delivered the steel produced in China makes the representatives of the European steel industry to ask for trade protection measures when faced to the assault given by the competition from outside the community block [4, 9, 11].

Romanian metallurgy, unfortunately, after 1989 has suffered a quasi-total setback. The decline and involution of Romanian metallurgy has multiple causes, among which we mention: very high specific consumptions (both energy, and of materials), significant reduction of the sale markets, replacement of domestic capital with the foreign and fraudulent privatizations [10, 12, 13].

2. Description of the main metallurgical companies in Romania

2.1. Companies in the steel industry

Targoviste Special Steel Compound (formerly Mechel Targoviste) is a company in the steel industry in Romania, owned by the Nikarom Invest company in Bucharest. Targoviste Special Steel Compound (**Figure 1**) was privatized in 2002; it was taken over by the Conares Trading company, registered in Switzerland. The transaction value was about 35 million dollars. Conares later became part of the Russian group Mechel.

In February 2013, Mechel sold all its properties in Romania, including the plant in Targoviste, for the symbolic sum of 230 Lei to the Invest Nikarom company from Bucharest and Mechel Targoviste returned to the old name of Special Steel Compound Targoviste.

In 2013, the company consumed about 0.4 TWh of energy, nearly 1% of the total energy consumption of Romania [14, 15].

Since 1978, from its opening, Special Steels Compound Targoviste was equipped with modern technology for the production of special- and high-alloyed steels necessary for the development of national, civil and defence industry (e.g. most of the steel used in the construction of the nuclear power plant in Cernavoda was developed in Targoviste).

In Targoviste plant, the forged blocks and bars (FBB) department was created and it was equipped with a capital infusion of over $90 million in quotation of the 1980s, and with radial

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Figure 1. Special Steels Compound Targoviste.

forging machines of the latest generation [In 2010, the department owned only the FBB equipment in Southeast Europe which is having NATO certificates.

Number of employees in 2013: 2000

- Fiscal value
  - 2013: 430.5 million Lei (97.7 million Euros)
  - 2010: 851.7 million Lei (202.3 million Euros)
  - 2009: 529.6 million Lei
  - 2006: 646.8 million Lei (231 million dollars
- Net income
  - 2010: 155.1 million Lei (36.8 million Euros)
  - 2009: 100 million Lei
  - 2006: 8.9 million Lei (3.2 million dollars)
  - 2005: 56.8 million Lei

Losses for the years 2005, 2009 and especially 2010 should be noted. Thus, according to www.wall.stret, in 2010, the fiscal value of the steel plant Mechel Targoviste (COS) increased by 61% to 851.7 million Lei (202.3 million Euros), but the company had losses for the second consecutive year, according to preliminary financial results forwarded by Bombay Stock Exchange (BSE).

The Special Steels Plant (COS), the largest employer in Targoviste, which is struggling to survive insolvency from the beginning of the year, is strongly affected by the export of scrap mainly in Turkey, which keeps the price of the main raw material with an average of about 80% of production costs at a high level and reduces the competitiveness of the plant for export.

As long as we export scrap, it is an advantage for the Turks to bring us steel-concrete because they succeed to do the so-called full on full transport. It is interesting to see if Germany or France exports scrap. One realizes that they also collect scrap metal, 'It is about what tax and policies we apply'. In the first half of the year, COS Targoviste business was reduced three times from 481 to 136.2 million Lei (31 million Euros) and the local production of steel-concrete collapsed in the same period by 76% to 44,000 t. On the other hand, imports of steel-reinforced concrete rose between 2010 and 2012 by 17% to 324,000 t.

A compound/plant cannot be closed and opened as if it was a shop door. One needs to find solutions so that it works all the time, even when it does not have enough orders because it has large expenditures even when not producing anything. If an electric arc furnace (EAF) is stopped, its durability (refractories and other components) drops to repeated restarts.

The new shareholder with the trustees is trying to recover the company going through insolvency since February this year after several wrong decisions taken by Russian management from Mechel, such as export of concrete steel with increased costs that led the plant to face loss after loss. After this strategy failed, Mechel cut off the funding of Targoviste plant and sold it for nothing in order to escape the loss of tens of millions that hung heavily in the balance sheet of the group.

From November last year until March, the production of The Special Steels Targoviste (formerly Mechel Targoviste) was completely stopped and its employees had lost hope of ever returning to work.

The consequences of these closures have been worst for the Romanian economy and turned the steel-concrete domestic market upside-down. For example, the closure of the Mechel enterprise led, in the first half of the year, to a fall of the concrete steel production in Romania by 76% to 44,000 t.

The COS Targoviste business fell in the same period of time by 3.5 times, from 481 to 136.2 million Lei (31 million Euros), while the compound has been mainly closed. The losses of this plant were reduced in the same period from 59.5 to 19.3 million Lei.

The Mechel production cuts have also led to import steel-reinforced concrete to invade the Romanian market, reaching up to 17% in the last 2 years, while last year they reached to 324,000 t, more than half of our internal needs. This is happening while the actual production capacity of COS Targoviste could cover the entire consumption of steel-concrete in Romania, which contracted sharply in recent years, currently reaching 550,000–600,000 t.

After the takeover by Nikarom Invest, a company controlled by Svetlana Chumakova and Victor Chumakova, the parents of Olga Chumakova, former head of Mechel representative in Bucharest, the company became insolvent on its own request/initiative and the entire

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production flow was redesigned so that the plant would manage on its own without any financial help from outside.

The new shareholder from COS Targoviste took harsh restructuring measures, which focused on the reduction of employees and merging the production departments in order to minimize costs in the context of having lost orders from traditional customers because of inactivity.

However, the management has taken steps to reintroduce special steels with higher added value into production; they made minimal investment in new compressors to reduce energetic costs and geared towards technological processes, such as heat treatment, to obtain steels in order to reduce the cost to a minimum, while increasing market competitiveness.

An entire city depends on the outcomes of these reorganizations, a city that, in the last two decades, was devastated by deindustrialization and loss of jobs from this large plant.

In the last decade, Targoviste, a city that relies on three steel companies on the industrial platform from COS Targoviste, has lost about 16,000 inhabitants, or 17.8% of the total between 2002 and 2012. During this time, more than 4000 people who were working at the Mechel steel large plant Targoviste have lost their jobs. There were 6160 employees in 1999, and only 2100 employees last year.

The plant currently has about 1370 employees, layoffs taking place a few months ago when 530 people left the company. Even so, COS Targoviste remains the largest employer in the city of Targoviste, and on the same industrial platform there are two more companies supporting the city employment, namely Steelinox controlled by the South Koreans from Samsung, which has 840 employees, and Erdemir with Turkish shareholders, which employs about 340 people.

Before 1989, the large plant had 5500 employees. There were 11 electric arc furnaces for steelmaking. The plant capacity was about the same but it used another kind of metallurgy. The furnaces were far smaller and while a batch takes 60 minutes these days, in the old furnaces it took about 3–4 hours. Now there is one oven modernized furnace with three oxy-fuel burners that can sustain a continuous production of 500,000 t/year.

Although before 1989 Romania was a closed, low performance economy, the plant in Targoviste managed to export to countries such as Syria, Iraq and CAER region (USSR, East Germany, Bulgaria, Poland, Czech-Slovakia, Hungary).

Restricting the plant activity only in the local market, 60% from exports as it had in 2011 eliminated, has hit jobs in the factory. After recent restructuring, tasks were redistributed so that two people can now do what three people used to do years ago.

One of the major problems the plant is facing is that exports of scrap, particularly in Turkey, keep the scrap price at a high level, increasing the costs of steel produced internally.

Besides imports, the plants are facing new competition from the Italians from STG Group, which reopened the mill production in Focsani last year and compete in the segment of reinforced concrete.

To increase efficiency, the plant in Targoviste has launched the so-called special steels into production this month; these are types of steel with higher added value than the steel-concrete, trying to gradually recover the market. In the first month 2500 t of special steel will be produced, less than 10% of the capacity of the mill, while the old customers have shifted to other suppliers when the plant was closed, and now they are purchasing smaller quantities from the plant in Targoviste.

The plant lost one of the most important customers in the domestic market, Dacia Pitesti, shortly after Dacia has been taken over by the French from Renault, who has abandoned forges and other equipment of steel processing supplied by Targoviste plant to produce the car parts, and now car parts are imported from Turkey or France.

The production facilities now in industrial heath on the platform in Targoviste testify to the impressive growth that the steel industry had taken here before 1989. Shortly after they have taken over the plant in August 2002, the Russians from the Mechel group closed the Steelworks number one and the departments responsible for steel processing and have not been reopened them so far.

The Steelworks closed in 2004 produced stainless steel and high alloy steels such as those for the food industry (cooking pans, cutlery, etc.) and for the medical industry, mainly medical instruments requiring more special steels. Between 1980 and 1986, the steelworks produced special steels for the nuclear program, respectively, the nuclear power plant in Cernavoda.

The Russians have motivated the closure of these compounds through lack of demand and outdated technology which did not allow competing with exports from neighbouring countries, such as Germany. Currently most of the market is covered by imports from Germany.

COS Targoviste business is decreased by 3.5 times in the first semester, from 481 to 136.2 million Lei (31 million Euros)

- Losses in Targoviste plant decreased in the first half of the year by three times to 19.5 million Lei (4.4 million Euros).
- Romania's production of steel-concrete decreased by 76% from 180,000 to 44,000 t in the first semester.
- Romania's imports of steel-concrete increased by 17% to 324,000 t, during 2010–2012.
- The number of employees at COS Targoviste decreased from 5500 before 1989 to 1370 employees these days.
- The price of a tonne of special steel reaches 690 Euros, compared to 490 Euro/t for concrete steel.
- An employee of COS Targoviste earns an average salary of 1500–1600 Lei in total including bonuses and other benefits.
- One tonne of steel-concrete used to cost about 3100 Lei in 2007 and now it is a little above 2000 Lei.

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2.1.1. ArcelorMittal Galati

ArcelorMittal Galati, the largest steel mill in Romania (which currently has around 6000 employees) will suppress about 1500 jobs by 2020 by natural wastages, but will hire around 100 young workers annually came from the schools of apprentices.

Since 2009 until now, the company of Indian billionaire Lakshmi Mittal has invested in Galati over 350 million Euros. A part of the financial losses is found in the modernizations made to the unit and financed by the group.

Another major investment, inaugurated at the beginning of the year, at the heavy plate mill is the hot leveller for flawless surface, which ensures that the plate is flat, a project that costs 14 million Euros.

The company is planning to maintain an annual investment budget of over 25 million Euros.

At the same time, the parent company has set a target of the achievement in 2017 of the break-even point (profitability threshold): the level at which the revenue shall be equal to the expenses and the company has no profit or loss. In **Figure 2**, the diagram of the break-even method is introduced.

ArcelorMittal Galati, former Sidex Steel Mill, was bought from the state in 2001 with 70 million Euros by Indian billionaire Lakshmi Mittal, who has assumed the commitment to invest 350 million Euros.

The largest steel producer in the world has stated that at the capital increase is to be added 1 billion dollars from the sale of a 35% participation of Gestamp shares, Spanish company

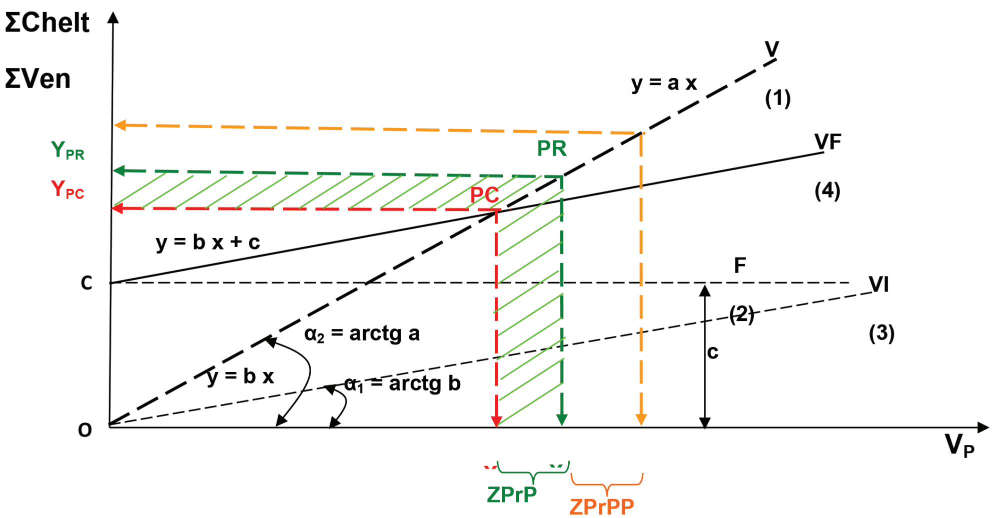

Figure 2. Graphical representation of the break-even method ZPrP: Expected profit area; ZPrPP: Up expected profit area.

specialized in the production of steel for the automotive industry. The Mittal family, which at the end of last year had 39.4% of the shares in the steel mill, will take part in the capital increase with 1.1 billion dollars.

This capital increase combined with the sale of the minority participation in Gestamp will accelerate the company's plans aiming at reducing the debt and will allow us to decrease the net debt at less than 12 billion dollars. This will ensure that the business will remain resilient in any context of the market and places ArcelorMittal in a position of power from which we can further improve our performance.

In parallel, ArcelorMittal has announced that in 2015 its operating profit has declined by 28% up to 5.2 billion dollars while sales were reduced by 19% to 31.9 billion dollars. The year 2015 was a very difficult year for the steel and mining industries. Although the demand on our main markets has remained strong, prices have been significantly reduced in the last year as a result of excess capacity from China.

Two years ago, ArcelorMittal has revised on two occasions the profit estimates in the conditions under which the Chinese exports have led to lower prices for steel in Europe and the USA, the main markets of the ArcelorMittal Group. In 2015, steel exports from China have increased by a fifth up to the record value of 112 million t, so that in November the prices for steel in Europe have reached the lowest level after 2007, with 75% below the maximum level.

In these circumstances, ArcelorMittal will launch a new 5-year plan, hereinafter called the 'Action 2020', intended to improve the results on the five operational segments and will return to an operating profit of over 85 dollars/t, under the conditions in which the last year has dropped up to 62 dollars/t.

ArcelorMittal is the largest steel and mining company in the world, present in more than 60 countries, in 19 of them with their own production units. In Romania, ArcelorMittal owns production units in Galati, Iasi, Roman and Hunedoara.

The company reported a loss of 6 billion dollars in the fourth quarter, which raised the negative result for the entire year passed to 7.95 billion dollars. During the last 3 months of 2014, ArcelorMittal recorded a loss of 711 million dollars, while per the full year registered a loss of 1.1 billion dollars.

The massive loss in the fourth quarter of last year also includes revaluation of assets of 4.8 billion dollars related to the operations of iron ore production.

2.2. Companies in the nonferrous metallurgy

Alro Slatina, the largest aluminium producer in Central and Eastern Europe, has recorded in 2015 a preliminary adjusted net income of 85 million Lei (19.1 million Euros), compared to a loss of 134 million Lei registered in 2014, having business growing by 15% of 2.3 billion Lei.

The Company S.C. Alro Slatina S.A. was established by the Romanian Government in March 1963, by building the first and the only Romanian aluminium plant in Romania, more precisely in Slatina, Olt County. In **Figure 3**, the registered office of this company is shown.

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Figure 3. Registered office and corporate headquarters of the company ALRO S.A. Slatina.

Alro ('the parent company' or the 'Company' or 'Alro') company established in March 1963 (under the name of 'Uzina de Aluminiu', 'Aluminium Plant') and organized under the Romanian legislation, is part of an Integrated Aluminium Production Group, covering the whole technological chain from bauxite up to obtaining processed products.

Vimetco N.V.: The Netherlands is the majority shareholder in Alro S.A., holding at present 84.19% of the company's shares. Vimetco N.V. is a private capital company which carries out business in Romania, China and Sierra Leone and is listed on the Stock Exchange in London. Alro Group comprises the following companies: Alro—manufacturer of aluminium (company listed at the Bucharest Stock Exchange), Alum—manufacturer of alumina (company listed at the Bucharest Stock Exchange), SMHL—manufacturer of bauxite, Vimetco.

Aluminium production has started in 1966 with a capacity of 50,000 t of aluminium per year.

By 1989, the production capacity went up to 263,000 t/year.

Because of the difficult economic conditions in Romania, in 1990–1991, production decreased to 110,000 t/year, subsequently increasing gradually up to 170,000 t.

In 1996, Alro was transformed into a joint stock company and, in October 1997, a 49% stake of the shares was listed on the Bucharest Stock Exchange, so that the government had the majority stake of shares (51%).

In 2002, the Romanian state has sold for an amount of 11.5 million dollars, six packages of 10% of Alro's shares to the investor Marco Group, which already owned (directly and indirectly) 41.85%, the latter thus becoming the majority shareholder.

In 2006, Alro merges with Alprom Slatina and Alum Tulcea. In April 2007, Marco Group changes its name into Vimetco. At present, Vimetco N.V. owns over 87% of the shares in Alro. Since Alro's privatization in 2002, Marco Group has invested in the company over 210 million USD, which have enabled the improvement of environment protection, as well as the increase by 20% of production (at 184,000 t), compared to the period prior to privatization.

The operating profit (earnings before interest, taxes and amortization (EBITA)) registered in 2015 went up to 198 million Lei, six times higher than in 2014. The net profit of the company was 9.6 million Lei in 2015, compared to a loss of 109 million Lei registered in 2014.

The investment of over 550 million dollars made in the past 11 years has helped Alro to consolidate and to extend its product portfolio to reduce its specific power consumption and final costs. Moreover, the reduction in the support scheme for the renewable energy sector has the role to eliminate distortions faced by the non-ferrous metallurgical industry.

The results are also due to the programs for increasing production capacity for the products with high added value, as well as for increasing the operational efficiency and for reducing energy dependence.

Thus, the cost of raw materials has declined also due to operation of the recycling waste aluminium capacity. About 10% of the primary aluminium produced in Alro originates from recycled waste. For this type of aluminium, electricity consumption is by 90% lower as compared to the one for producing electrolytic aluminium.

In 2015, total production of primary aluminium was of 271,000 t, growing from 263,000 t, registered in 2014. The production of processed aluminium was close to 79,000 t, compared to almost 78,000 t in 2014.

The company has secured in 2015 the amounts needed for investments, signing in December a loan facility with the Black Sea Trade and Development Bank, worth 60 million dollars, with a maturity of 7 years, out of which 15 million dollars have already been invested in the company during 2015.

At the same time, Alro has signed in December a revolving loan of 137 million dollars with a consortium of banks, with maturity in December 2017, which refinances, mainly, a loan from the European Bank for Reconstruction and Development, worth 120 million dollars, obtained in 2010.

The aluminium manufacturer signed in December the extension until December 2017 of another revolving loan of 180 million Lei, concluded with a commercial bank in December 2013. At December 31, 2015, the company had the whole facility of 180 million Lei used for the working capital.

The company's shares are held by Vimetco (Netherlands) at the rate of 84.2% and the Property Fund controls 10.2% of the titles, according to the data at the end of 2015.

CupruMin Abrud is a company in Romania whose main objective of activity is the extraction of non-ferrous metal ores. The main activity of CupruMin is the extraction and processing of copper ore from Rosia Poieni mine, selling the copper concentrate and precious metals, which is at present under concession to other companies: Energo Mineral, Cuprom and Ipronef.

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In 2008, the company carries out only the secondary activities, namely: extraction of andesite and limestone for construction, shooting, transport of goods and people. The company does not own mining objectives the closing of which has been approved by the government decision.

The company has been launched for privatization in May 28, 2008, at the starting price of 25 million Euros, but the process was interrupted after pre-consultation with European officials, according to whom the planned privatization does not comply with the rules on state aid. The second attempt for privatization was carried out in November 2008, at the starting price of 27 million Euros. In December 2008, the attempt of privatization was cancelled due to the unfavourable economic situation.

In November 2009, after more than a year of inactivity, the activity has been restarted. In March 2010, CupruMin had 420 employees and produced 400 t of copper ores per month.

The copper deposit at Rosia Poieni is estimated at 900,000 t (60% of Romania's copper reserves) which allows the continuation of exploitation for a period of at least 20 years.

In **Figure 4**, the processing plant of copper ores within CupruMin Abrud is shown.

In March 2012, the company Roman Copper Corp. Canada has been declared the winner of the tendering procedure for taking over the whole capital of CupruMin, owned by the Ministry of Economy.

CupruMin Abrud reduced the number of employees from 930 in 2005 to 500 in 2014, hence with approximately 47%.

Figure 4. The processing plant of ores within CupruMin Abrud.

2.3. Metallurgical companies in the field of processing and assembly

2.3.1. Metalurgica Aiud

The existence within the city of Aiud since the eighteenth century of a tradition in the production of steelwork and carpentry organized in guilds, led to the formation of a factory of building materials and steelwork in 1894, from which the current metallurgical enterprise has developed.

Since 1931 has turned in the factory of technical articles 'GENIUS', with headquarters in Brasov and since 1933 is registered in Aiud the existence of the 'Technical Laboratory Eng. A.I. Stoica', which besides the items for pressing and manufacturing metal packaging, produces also items for equipping the army.

Beginning with 1948, the enterprise was reorganized and has operated under the name of 'Uzina Rapid Aiud' and has had as manufacturing profile: pumps and appliances for the extinction of fires, steelwork items, metal wheelbarrows, simple agricultural machinery and consumer goods cast from cast iron.

Since 1951, the enterprise has been transferred as workshop for the maintenance and repair of rolling stock under the authority of 'Combinatul Siderurgic Hunedoara' (currently ArcelorMittal Hunedoara), changing their manufacturing profile into the repair of locomotives, repair services of wagons, casting cars and mine-cars.

As a result, at the end of 1954, the enterprise became a unit with economic management of its own under the name of 'Întreprinderea Metalurgică Aiud'('Metallurgical Enterprise Aiud') having a manufacturing profile of the repair of rolling stock on the entire sector of steel industry. Beginning with 1958, the enterprise focuses on the manufacture of metal constructions, machinery and spare parts for the steel industry, metallurgy and machine building industries.

In **Figure 5**, the access gate within the enterprise Metalurgica Aiud is shown.

Investments during 1966–1970 have been channelled mainly for the development of the hot sector, of centrifugal casting in particular of metal constructions and technological equipment.

Figure 5. Access within the enterprise Metalurgica Aiud.

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1970–1980 is the period in which the enterprise benefits from other two stages of development which have the effect of extending the existing production capacities, of increasing the level of integration, being assimilated new products with a high technical level. It is the period when the enterprise was considered to be the 'Chief Mechanic' of Romanian metallurgy and steel industry.

In December 2006, S.C. Metalurgica S.A. Aiud has sold its assets and stock-in-trade to the company S.C. Remarul 16 Februarie S.A. Cluj-Napoca, a company with 100% private capital. Thus was founded 'Remarul Metalurgica Aiud' as a working point of S.C. Remarul 16 Februarie S.A.

'Remarul Metalurgica Aiud' is an integrated company, having primary sectors that provide static or centrifugal castings, forged, mecano-welded unfinished goods and sectors of thermal treatments and mechanical processes.

With effect from April 15, 2008, the company bears the name of 'Metalurgica Transilvană Aiud'. This represents also the date of a new start in respect of the company's image. In **Figure 6**, aspects of the technological processes carried out in Metalurgica Aiud are shown.

Metalurgica Aiud was a company specialized on the production of machinery for metallurgy and metal constructions in Romania. It is the only producer in Romania for a range of products such as radiant tubes for heat treatment furnaces with controlled atmosphere, cast iron rollers, etc.

In June 30, 2005, the 'Serviciile Comerciale Române' (Romanian Commercial Services) through 'Contactoare Buzău', together with the businessman of Russian origin, Victor Ianusco and with Metalurgica's Employees Association, took over through AVAS the package of almost 74.5% of the share capital, for the amount of 5.3 million Euros. The business has proved to be a failure, whereas the consortium has not complied with the privatization contract, by not paying the shares.

In December 2006, the company has sold most of the assets to the company in the rail industry Remarul 16 Februarie for 3 million Euros. Remarul 16 Februarie took over also the employees of Metalurgica Aiud.

On March 13, 2013, the Court of Aiud decided officially the entry into bankruptcy of the company Metalurgica Aiud, after the company has not registered profit since 2008 and at the level of March, 2013 had over 6 million Euros in debts. The activity was stopped and the goods were put on sale.

Involution of the number of employees of S.C. Metalurgica Aiud was the following:

- 2003: 1200
- 2004: 1050
- 2005: 800
- 2010: 480
- 2010: 272
- 2013: 170

Figure 6. Technological processes carried out within S.C. Metalurgica Aiud.

2.3.2. Timken S.A. Ploiesti

Timken has 63 production facilities and service centres throughout the world, including eight production facilities in Europe located in Italy, France, Poland, Romania and Great Britain.

Timken has registered sales in worth of 3.1 billion dollars in 2014.

The American Group Timken will invest 237 million Lei (about 54 million Euros) in the manufacture of components for the automotive industry which they want to build next to Ploiesti, in Aricеștii Rahtivani, project for which they have received a state aid of 66 million Lei (15 million Euros).

Timken announced about 2 weeks ago that they would build next to Ploiesti, the second factory on the Romanian market, where they will produce tapered roller bearings for the global network of the group. Building of the unit with an area of 15,000 m^2 will start in the first quarter of 2016 and production is estimated to start in 2017.

In **Figure 7**, images with the location of Timken company in Romania are shown.

According to data published by the Ministry of Public Finance, the factory near Ploiesti will produce bearings, gears, gearboxes and mechanical components of the driveshaft. The state aid has been approved in November.

In **Figure 8**, examples of products of Timken S.A., Ploiesti, Romania are shown.

Timken started its activity on the Romanian market in 1997, when they took over from the state approximately 70% of the shares of the company Rulmenți Grei Ploiesti, within a transaction of about 40 million dollars.

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Figure 7. Images with the location of Timken company in Romania.

The new factory consolidates the group's presence in Europe. The investment supports the company's plan of strategic growth, DeltaX, that aims at geographical expansion, increasing competitiveness and acceleration of development and marketing activities of the products.

The American group develops, manufactures and sells bearings, transmission systems, engines, gearboxes, chains and related products, offering a wide range of services for the reconstruction of propulsion and repair systems. Timken owns 63 factories and service centres in 28 countries and has 14,000 employees.

Figure 8. Products of the company Timken S.A. Ploiesti, Romania.

Timken sales decreased by 10% to 707.4 million dollars in 2015, mainly due to the fluctuations in exchange rates and to the decreasing demand on the global market. In 2014, the Group reported sales of 3.1 billion dollars.

3. Evolution of the steel industry in Romania

3.1. Benchmarks

- Creation of the legislative framework for implementing the principles of market economy and initiation of the process of decentralization of the state economy (since 1990).
- Ratification, by Law 20/1993 of the Association Agreement of Romania to the EU and adjacent to that of the Protocol 2 ECSC;
    - **i.** Establishing the Contact Group ECSC Romania, EU.
    - **ii.** Initiating full trade liberalization program.
    - **iii.** Initiating the complex process of restructuring the Romanian steel sector.
    - **iv.** Romania becomes for the first time, through the steel sector, Observer of the Steel Committee within the OECD (1993).
- Completion the privatization process of all existing integrated steel mills and manufacturing companies, with strategic investors: ArcelorMittal, Tenaris, Mechel, TMK, Samsung, Erdemir, etc. (2004).
- Adoption of a plan for restructuring of the steel sector in accordance with the requirements of the European Union and its implementation (GD No 213/2002).

3.2. Restructuring of the steel industry in Romania

- Drafting, approval by the Government of the 'Strategy for Restructuring the Steel Industry in Romania and of the Viability Individual Plans of Steel Companies for the Period

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2003–2008 (GD no.55 from January 2005) and validation thereof by the European Commission in the context of closing Chapter 6: Competition.

- Signing of the Treaty of Ascension to the EU within which under Annex VII are comprised:
  - Basic principles of the restructuring process of the steel sector.
  - Interface elements of government: steel companies.
  - Commitments taken in order to make viable in economic-financial terms until 2008 all companies in the steel industry.
  - Monitoring of the restructuring process; drafting by the Economy and Trade Ministry of the biennial reports and sending them to the European Commission.
- Obtaining the status of Full Participant of the Steel Committee within the Organization for Economic Cooperation and Development (October 2005).
- Carrying out of the restructuring process in the steel companies in accordance with the provisions of the strategic documents on the favourable background of steel demand on the market (2005–2008).
- Results of the restructuring process monitoring
  - The companies restructured ArcelorMittal Galati, ArcelorMittal Hunedoara, COS Targoviste, Industria Sârmei Câmpia Turzii, TMK Resita and Tenaris Calarasi represented in 2008 a percentage of over 90% of the domestic production of crude steel.
  - The state aid amounting to 1.52 billion Euros was targeted first on the financial restructuring (the conversion of debts into capital, prescription of debts for the utility suppliers) and to a lesser extent for the tax exemptions (VAT tax and the corporate profit).
  - After 2004, the state aid has not been granted and paid anymore, neither to the companies mentioned nor to any other steel producer in Romania.
  - The production capacities of steel, the lamination capacities, the number of employees in the steel industry has been reduced.

In **Figure 9**, the involution of production capacities and, in **Figure 10**, the involution of the number of employees in the steel industry of Romania, are shown.

We note drastic reduction of production capacities in 2003 as follows:

- By 46.3% for steel making capacities (from 17,505 t in 1993 to 9400 in 2003).
- By 60.8% for semi-finished products capacities (from 15,125 t in 1993 to 5925 in 2003).
- By 10.9% for hot rolled finished products capacities (from 11,250 t in 1993 to 10,020 in 2003).

We see drastic reduction of the number of personnel, as follows:

- By 58.2%, from 143,615 in 1993 to 60,000 in 2003.
- By 45.4%, from 60,000 in 2003 to 32,788 in 2008.

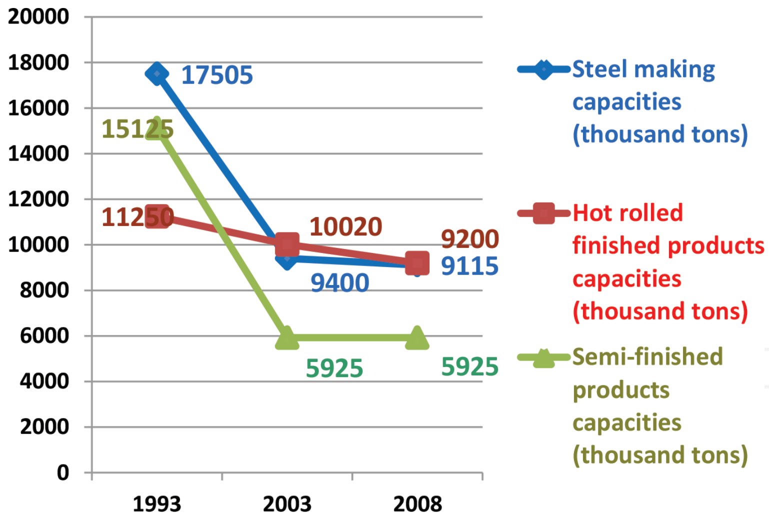

Figure 9. Involution of production capacities.

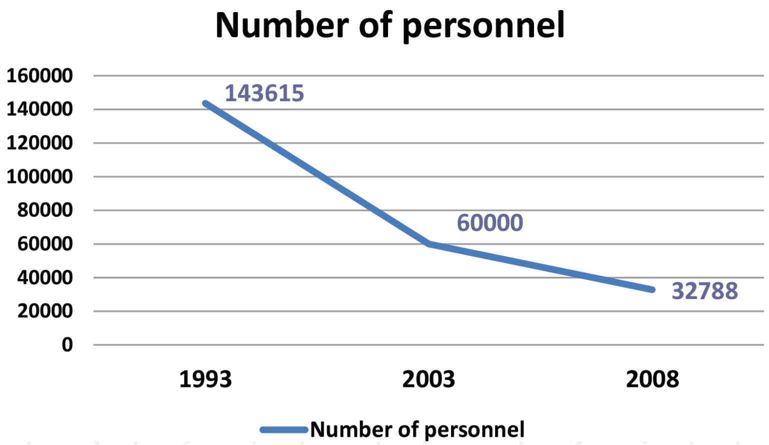

Figure 10. Involution of the number of personnel in the steel industry.

- Investments were made in technology and environmental protection amounting 787,531 million dollars.
- The restructuring benchmarks, as they were set out in the restructuring strategy, the viability individual plans and Annex VII of the Treaty of Accession (viability, productivity and cost reductions) were mostly achieved.
- The conclusion of the European Commission noted in 'COM 476 final: Third monitoring report on steel restructuring in Romania' was that the restructuring process during the transitional period has ended, in general, successfully.

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3.3. Impact of the global crisis on the steel sector in Romania

- The start of the global economic-financial crisis, beginning in the second semester of 2008, has affected also the Romanian economy/steel industry.
- The significant decrease in demand for steel products resulted in performance indicators lower than those forecasted.

We note a drastic reduction at the level of 2009 by 54.5% (**Figures 11** and **12**).

- Withdrawal from Romania at the beginning of 2013 of the Mechel Group by selling the main share packages from COS Targoviste, Industria Sârmei Câmpia Turzii, Ductil Steel Buzău, Laminorul Brăila; the entry into insolvency of these companies and start of the process of judicial reorganization.
- The increase in imports particularly from non-EU countries (Ukraine, Turkey, China, etc.), has led to an increase in the trade deficit to about 1 million t of steel products (e.g. reinforcing steel, wire rod for drawing mills, flat coated products, semi-finished products, etc.).
- Uncontrolled and unpredictable growth of costs with the electrical energy, having as origin: the increase in energy price from producers; the increase of prices for services (transmission, distribution, etc.); implementation of the energy legislative package: climate changes; renewable energy, cogeneration fee.

In **Table 1**, the evolution of hot rolling capacities between 1993 and 2015 is shown.

We notice that the major differences between 1993 and 2015 can be found on Siderurgica Hunedoara/Arcelor Hunedoara (−9000 t, respectively, from 9600 to 600 t) and on Ispat Sidex Galati/ArcelorMittal Galati (−4200 t, respectively, from 11,000 to 6800 t).

In **Figure 13**, the evolution of steel, hot rolled steel finished products and tubes production is shown.

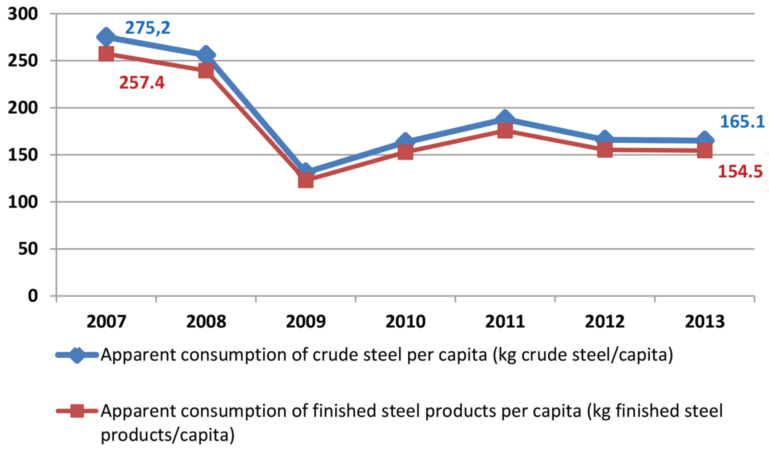

Figure 11. Evolution of the apparent consumption steel/finished products.

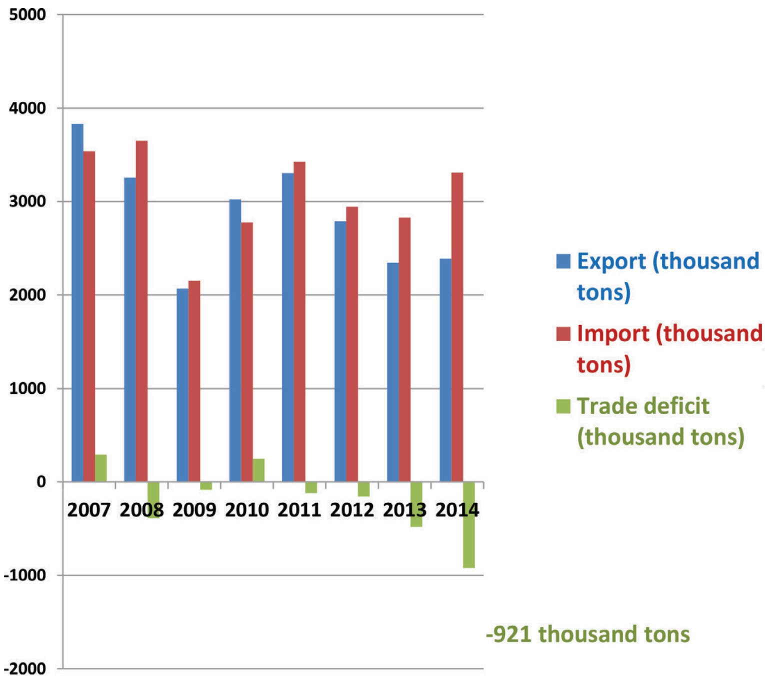

Figure 12. Evolution of the trade deficit of the iron and steel products.

3.4. Implementation of the recommendations contained in the action plan for a competitive and sustainable steel industry in Europe

- The policies in the field of energy, climate, resources and energy efficiency in order to stimulate competitiveness.
  - In order to reduce the impact of the factors mentioned on electricity price have been taken support measures for consumers (reduction of the number of green certificates, postponement of payment until 2017, reduction of the cogeneration tax, etc.), validated by normative acts.[1]
  - The State aid scheme regarding exemption of certain categories of final consumers of the enforcement of Law no. 220/2008 has been approved establishing the system for promoting energy production from renewable sources, drawn up based on the 'Guidelines on State aid for the environment and energy for the period 2014–2020',

[1]The Law 23/2014 for the approval of GDO 57/2013 regarding amending and supplementing Law no. 220/2008 establishing the system for promoting energy production from renewable sources.The Government decision no. 224/2014 for the approval of the share of electricity produced from renewable energy sources which benefit from the promotion system through green certificates for 2014.Order of the President of the ANRE no.119/2013 on the approval of the contribution for high-efficiency cogeneration and of some provisions for billing thereof.

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MINISTERUL ECONOMIEI, COMERŢULUI ŞI TURISMULUI

ROMANIA

EVOLUTION OF HOT ROLLING CAPACITIES BETWEEN 1993 - 2015
(thousand tons)

Steel Plant	Capacity 1993	Capacity 2003	Capacity 2008	Capacity 2015	Difference 1995-2015
ISPAT SIDEX Galati/ ARCELORMITTAL Galati	11.000	6.800	6.800	6.800	-4.200
SIDERURGICA Hunedoara/ ARCELORMITTAL Hunedoara	9.600	3.920	3.440	600	-9.000
COS Targoviste/ SC NIKAROM INVEST SRL	1.330	1.330	1.330	550	-780
IS Campia Turzii/ SC NIKAROM INVEST SRL	765	685	685	0	-765
CS Resita/ TMK Resita	1.510	1.390	1.050	0	-1.510
CS Otelu Rosu/ SC NIKAROM INVEST SRL	300	300	300	0	-300
DONASID Calarasi/ TENARIS Silcotub Zalau	1.870	1.520	1.520	0	-1.870
TOTAL	26.375	15.945	15.125	7.950	-18.425

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Table 1. Evolution of hot rolling capacities between 1993–2015.

adopted by the European Commission (COM) on April 9, 2014, being under implementation.

- The legal framework for the sale of certificates of greenhouse gas emissions has been created, i.e. the use of revenues obtained and for financing projects which are aimed at reducing the greenhouse gas emissions, including financing of research and development in the field of climatic changes.
- Disparities in prices and average costs of energy, between the EU and its main competitors, shall be reduced in terms of achieving a regional market energy—one of the strategic objectives of the government.
- All steel companies have in progress investment programs for improving energy efficiency/reduction of energy consumption and increasing the competitiveness of steel products.

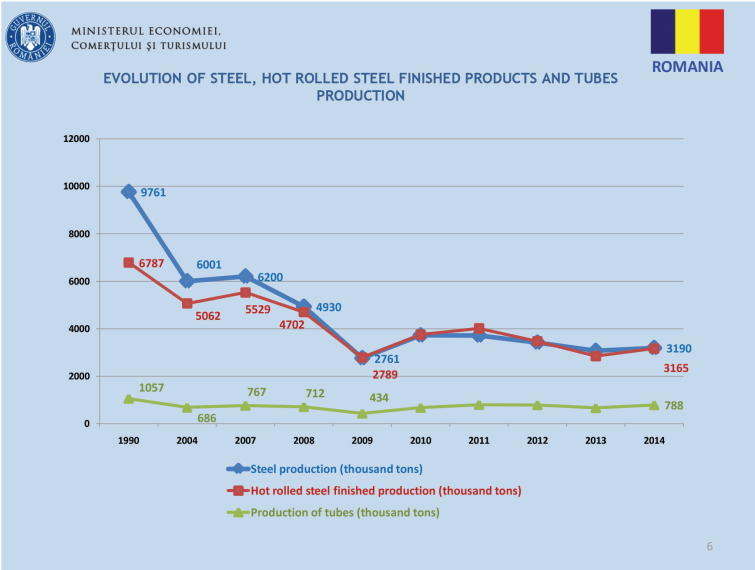

Figure 13. Evolution of steel, hot rolled steel finished products and tubes production.

- Social dimension: restructuring and the needs for competences.
  - Ensuring the legal framework for vocational training and retraining of workers by:
    - Law no 76/2002 on the unemployment insurance system and stimulation of employment, with subsequent amendments and supplements.
    - Law no. 279/2005 on apprenticeship at the workplace, with subsequent amendments and supplements.
  - The measures that concern the vocational training of workers in order to increase the adaptability to structural changes of the labour market have been proposed for additional financing from the European Social Fund through the 'Partnership Agreement 2014–2020'.
  - Structural Funds will also be used on a priority basis during the present programming period (2014–2020) for financing pre-layoff and stimulation of persons seeking employment.
  - It has been approved 'The National Strategy for Employment 2014–2020 and the Action Plan for the period 2014–2020 for implementing the National Strategy - GD 1071/2013'.
  - The social partners have made concrete proposals to governmental institutions empowered on the deficit of competencies.
  - The associations of employers are concerned with the continuing vocational training of employees (Exp. TenarisSilcotub Zalau, University Training Centre; ArcelorMittal,

Centre for Professional Training of employees and future employees; TMK, Centre of vocational training/training of employees, etc.)

- In 2013, it has been promoted the project 'Social Plant from Câmpia Turzii', in worth 7.1 million Euros, co-financed from the European Globalization Adjustment Fund (EGF); the project is addressed to workers made redundant (approximately 1000 employees) from the plant Industria Sârmei Campia Turzii.

3.5. Privatization, modernization/restructuring and monitoring between 2004 and 2008

- Completion of the privatization of all integrated steel mills and manufacturing companies, with strategic investors: ArcelorMittal, Tenaris, Mechel, TMK (2004).
- Starting the complex process of restructuring and modernization of steel sector by implementing the 'Restructuring strategy of Romanian steel industry and of the viability individual plans of steel companies for the period 2003–2008' validated by the European Commission in the context of closure of the negotiation of Chapter 6: Competition of the Accession Treaty.
- Romania became full participant within the Steel Committee of OECD, following the invitation received in 2005.
- Monitoring the Romanian steel sector by the European Commission (2005–2008).
- Conclusion of the European Commission published in 'COM (2010) 476 final: Third monitoring report on steel restructuring in Romania' stating that the restructuring process in the transitional period ended, generally, with success.

In the **Table 2**, the state of steel plants privatization in Romania is shown.

In **Figure 14**, the involution of the number of personnel employed in the Romanian steel industry is shown.

The striking decreases noted are as follows:

- Decrease by 58.2% between 1993 (143,500 absolute figure) and 2003 (60,000 absolute figure).
- Decrease by 45.4% between 2003 (60,000 absolute figure) and 2008 (32,788 absolute figure).
- Decrease by 41.2% between 2008 (32,788 absolute figure) and 2014 (19,300 absolute figure).

Consequently, the total reduction in the number of personnel from Romanian steel industry between 1993 and 2014 was of 86.6%, respectively, from 143,615 in 1993 to 19,300 in 2014.

3.6. Aspects of research and development agenda for metallurgical industry in Romania

The metallurgical sector in Romania has lost more than 200,000 jobs in the last 20 years, and it is one of the most affected areas of activity in our country because of the measures implemented following the agreements with the International Monetary Fund (IMF).

MINISTERUL ECONOMIEI, COMERȚULUI ȘI TURISMULUI

ROMANIA

State of steel plants privatization in Romania

Company	Year of privatization	The majority shareholder at privatization	2015	Remarks
ISPAT - SIDEX Galati	2001	LNM Holdings	ARCELORMITTAL Galați	Flat products
SIDERURGICA Hunedoara	2003	LNM Holdings	ARCELORMITTAL Hunedoara	Long products
COS Targoviste	2002	Conares MECHEL Group	SC NIKAROM INVEST SRL	Long products
IS Campia Turzii	2003	Conares MECHEL Group	SC NIKAROM INVEST SRL	Long products
Otelu Rosu	2002	Gavazzi Steel Italia	SC NIKAROM INVEST SRL	Long products
CS Resita	2004	T.M.K. Sinara	TMK Reșița	Tubes
Donasid Calarasi	2003	Beltrame Italia	TENARIS Silcotub Zalău	Tubes

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Table 2. State of steel plants privatization in Romania.

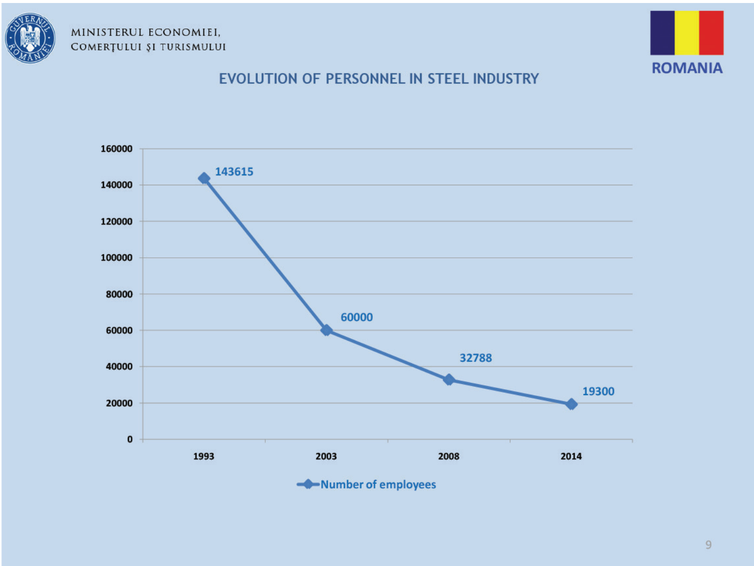

Figure 14. Involution of the number of personnel employed in the Romanian steel industry.

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The main milestones in the involution of the siderurgical sector in Romania were the following:

- Creating the legislative framework for implementing the principles of the market economy and triggering the decentralization process of the state economy (since 1990).
- Ratification by Law 20/1993 of the Association Agreement of Romania to EU and adjacent to it of the Protocol no. 2 ECSC;
  - **i.** Establishing the Contact Group ECSC Romania, EU.
  - **ii.** Initiation of the full trade liberalization program.
  - **iii.** The foundations of the complex process of restructuring of the Romanian siderurgical sector.
  - **iv.** Romania becomes in national premiere due to the siderurgical sector, Observer Member of Steel Committee from the OECD (1993).
- Complete privatization of all the integrated siderurgical enterprises and manufacturing companies, with strategic investors: ArcelorMittal, Tenaris, Mechel, TMK, SAMSUNG, etc. Erdemir (2004).
- Adopting a siderurgy restructuring plan in accordance with EU requirements and its implementation (Government Decision no. 213/2002).
- Development, approval by the government of the 'Restructuring Strategy of the Siderurgical Industry in Romania and of the Individual Viability Plans for the Siderurgical Companies in 2003–2008 (GD no. 55 of January 2005) and its validation by the European Commission in the context of closing Chapter 6: Competition
- EU Accession Treaty Signing (March 2005) in which in Annex VII there are comprised the following:
  - The basic principles of the siderurgy restructuring
  - Interface elements of government: siderurgical companies
  - The commitments taken in order to ensure the economic and financial viabilization of all siderurgical companies by 2008
  - Restructuring process monitoring; drawing by the MEC of the biannual reports and sending them to the European Commission (2005–2008).
- Becoming a Full Member of the Steel Committee of the Organization for Economic Cooperation and Development (October 2005).
- Performing the Restructuring Process in the Siderurgical Companies in accordance with the provisions of the strategic documents amid the favourable demand for steel in the market (2005–2008).
- The Results of the restructuring monitoring are as follows:

- The restructured companies ArcelorMittal Galati, ArcelorMittal Hunedoara, COS Targoviste, Campia Turzii Wire Industry, TMK Resita and Tenaris Calarasi represented in 2008 a share of above 90% of the Romanian crude steel production.
- The state aid worth of 1.52 billion Euros was focused first on the financial restructuring (debt to equity conversion, prescribing debts for utilities) and to a lesser extent on the exemption from taxes (VAT and corporate income tax).
- After 2004, it was neither given nor paid any state aid, to any of the companies mentioned or to any other steel producer in Romania.
- There were reduced the steel production capacities, the lamination capacities and the number of employees in the steel industry

3.7. Implementation of the recommendations contained in the action plan for a sustainable and competitive siderurgical industry in Europa COM (2014–2020)

- The policies on energy, climate, resources and energy efficiency to boost competitiveness:
  - To reduce the impact of the factors mentioned on the electricity price, support measures have been taken for consumers (by reducing the number of green certificates, payment deferral until 2017, the cogeneration tax reduction, etc.), validated by laws.
  - It was approved a state aid scheme exempting certain categories of end users from Law no. 220/2008 in order to establish the system for promoting energy production from renewable sources based on 'The Guidelines for Environment and Energy Aids for 2014–2020' adopted by the European Commission (COM) on April 9, 2014, which is in the process of being implemented.
  - A legal framework has been created to capitalize the emissions of greenhouse gases, respectively, the use of the revenues obtained for financing projects aimed at reducing emissions of greenhouse gases, including financing research and development on climate change.
  - Disparities on prices and average costs of energy between the EU industry and its main competitors will be reduced in order to create the regional energy market—one of the government's strategic goals.
  - All siderurgical companies have on-going investment programs for improving energy efficiency/reducing energy consumption and increasing the competitiveness of the siderurgical products.
- The social dimension: restructuring and the skill needs
  - Providing the legal framework for professional reconversion and retraining workers by means of the following:
    - Law 76/2002 on the unemployment insurance system and employment stimulation with the subsequent amendments and completions.
    - Law 279/2005 on apprenticeship at work, as further amended and completed.

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Law 23/2014 for approving Government Emergency Ordinance 57/2013 on amending and completing Law no 220/2008 in order to establish the system for promoting energy production from renewable sources.

Government Decision no. 224/2014 for the approval of the share of electricity produced from renewable energy sources which benefits from the promotion system through green certificates for 2014.

ANRE's President's Order No.119/2013 on approving the contribution for high efficiency cogeneration and certain provisions regarding its billing:

- Measures aimed at training workers to increase the adaptability to the structural changes of the labour market have been proposed for additional funding from the European Social Fund through the 'Partnership Agreement 2014–2020'.
- Structural Funds also will be used first and foremost in the current programming period (2014–2020) to finance pre-dismissals and stimulate people looking for a job.
- The 'National Strategy for Employment 2014–2020 and the Action Plan for the 2014–2020 have been approved in order to implement the National Strategy - GD 1071/2013'.
- The social partners have made concrete proposals to the authorized governmental institutions on skills shortages.
- Employers are concerned about the continuous training of employees (Exp. TenarisSilcotub Zalau, Academic Training Centre; ArcelorMittal. Centre for Professional Training of Employees and Future Employees; TMK, Professional Training Centre for Employees, etc.).
- In 2013 'The Campia Turzii Social Enterprise' project was promoted amounting to 7.1 million Euros, co-financed from the European Adjustment Fund for Globalization (EGF); the project addresses the dismissed personnel (approximately 1000 employees) from Campia Turzii Wire Industry Enterprise.

According to the '**Winter Forecast for 2015 of National Commission of Prognosis,**' the projection of the main indicators for the 2014–2018 is as follows:

	2013	2014	2015	2016	2017	2018
GDP—real increase (%)	3.4	2.9	2.8	3.0	3.3	3.5
Industrial production for the metallurgical/siderurgical industry (%)	−7.8	4.4	1.8	2.3	3.3	3.6

The industrial production forecast shows a slight recovery of metallurgical/siderurgical industry compared to 2013; but in order to achieve this, the metallurgical companies in Romania should be concerned with the following:

- alignment generalization with best available techniques (BAT) in metallurgy in order to optimize their environmental performance;
- maintaining the activity at a competitive level compared to the evolution of the energy costs;

- increasing productivity through improving the use of the material and energy resources;
- further implementation of the provisions of HG. Nr. 495/2014 on instituting a state aid scheme to exempt certain categories of end users from Law no. 220/2008 in order to establish the system for promoting energy production from renewable sources, with the subsequent amendments and completions;
- further implementation of the recommendations of the 'Action Plan for the Future of the Siderurgical Industry [COM (2013) 407]' on energy efficiency, CO_2 emissions reduction, allocating funds from capitalizing on emissions, for research and development, accessing structural funds for professional reconversion, etc.

4. The prospects of metallurgical industry in Romania

- According to the **'2015 Winter Prognosis of the National Prognosis Commission'** projection of the main indicators for the period 2014–2018 shall be in the following format (**Table 3**).
- Industrial production forecast shows a slight recovery of the metallurgical/steel industry compared to 2013; but for achieving this, metallurgical companies in Romania should be concerned with the following goals:
  - generalization of alignment to the best available techniques (BAT) in metallurgy in order to optimize their environmental performance;
  - maintaining activity to a competitive level in relation to the progress made in the energy costs;
  - to increase productivity by improving the use of material and energy;
  - to continue the implementation of provisions of 'GD. No 495/2014 on the establishment of a state aid scheme to exempt certain categories of end users from Law no. 220/2008 establishing the system for promoting energy production from renewable energy sources, with subsequent amendments and supplements';
  - to continue implementing the recommendations of the 'Action Plan for the future of steel industry [COM (2013) 407]' on energy efficiency, to reduce CO_2 emissions, to allocate funds from the sale of the certificates of emissions to research and development, to access the structural funds for professional reconversion, etc.

	2013	2014	2015	2016	2017	2018
GDP—actual increase in %	3.4	2.9	2.8	3.0	3.3	3.5
Industrial production for the metallurgical/steel industry %	−7.8	4.4	1.8	2.3	3.3	3.6

Table 3. Percentage changes compared to the previous year (%).

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5. Technical-economic components specific to metallic materials industry

In the industry of the metallic materials are used several kinds of energy for operation, among which the most important are the following:

- *the burning of fuels* and
- *the electrical energy*.

In the case of technical-economic analyses which are made in metallurgical enterprises, the consumptions in the area of the two energy sources (furnaces with combustion and electric furnaces) should be coherently expressed by the same indicator, which is the *specific consumption of primary energy*. The equivalence of the various forms of primary energy E_{p} [HJ/t] depending on the energy registered $E_{\hat{\imath}}$ [HJ/t or Kwh/t] to a certain furnace shall be made using the relation:

$$E_{\mathrm{p}} = eE_{\hat{\imath}} \tag{1}$$

where

$E_{\hat{\imath}}$ is the consumption registered (or calculated) in kWh/t to the electric furnaces and MJ/t to the combustion units.

e is the coefficient of equivalence.

The primary energy is the energy in the natural sources (deposits) of *fossil or primary fuels* (coal, natural gas, oil). It may be assessed based on the quantity of fossil fuel (m_{cf}) and on the calorific value of the latter in raw state H_{cf}.

$$E_{\mathrm{p}} = m_{\mathrm{cf}} \cdot H_{\mathrm{cf}} \ \ [\mathrm{MJ}] \tag{2}$$

In the case where to combustion furnaces, energy consumption is given in the form of the specific consumption of fuel B_{s}, $[\mathrm{kg};\mathrm{m^3N\ comb./t}]$ with lower calorific power H_i, then the relation of equivalence is:

$$E_{\mathrm{p}} = e \cdot B_{\mathrm{s}} \cdot H_i \tag{3}$$

If it is intended to calculate the consumption of primary energy in consumptions of conventional fuel of calorific value $H_{c.c} = 29\ \ \mathrm{MJ/kg}$, then the transformation is given by:

$$E_{p.c.c} = \frac{E_p}{H_{c.c}}, [\mathrm{kg\ c.c/t}] \tag{4}$$

In the relations from above, e represents the equalization coefficients in primary energy of the various types of energies used by the unit. The recommended values for these coefficients are as follows:

- $e_c = e_p = e_{g.n} = 1$ MJ/MJ for coal, crude oil and natural gas.
- $e_k = 1.2$ MJ/MJ for coke and
- $e_{e.e} = 10$ MJ/KWh for the case of using electricity.

In order to understand the essence of the transformation of energy consumption registered at the metallurgical thermo-technological facility (E_p) in primary energy (E_p) we recommend consulting the scheme in **Figure 15** which shows the case of the electric arc furnace (EAF) for steelmaking based on consumption of electrical energy (EE) produced in electric power plants (EPP) fuelled with natural gas extracted from the deposit (D). The transport of natural gas and electricity is carried out on the routes T_1 and T_2.

In the analysis performed we should keep in mind:

- the extraction and transport T_1 of natural gas requires minimal energy consumptions and losses expressed as a percentage by the yield p_1;
- the conversion of natural gas into electrical energy in the EPP (electric power plants) is done with the yield p_2 (in Romania yield of the EPP is usually of 30–40%);
- the transport T_2 means the consumptions and losses measured by the yield p_3;
- consumption registered $E_{\hat{\imath}}$ to the EAC expressed in Kwh should be amplified with 3.6 in order to be obtained in MJ;

Based on the observations from above is obtained:

$$E_{p(z)} = 3.6 \frac{E_{\hat{\imath}(CAE)}}{p_1 \cdot p_2 \cdot p_3} \tag{5}$$

It may be inferred that:

$$e_{e.e} = \frac{3.6}{p_1 \cdot p_2 \cdot p_3} \tag{6}$$

If it is considered that $p_1 = p_3 \cong 1$ and is taken into account only p_2 with the value of 0.35, it results that:

$$e_{ee} = \frac{3.6}{0.35} \cong 10 \text{ MJ/Kwh} \tag{7}$$

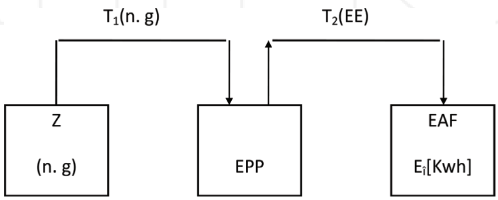

Figure 15. The route of transforming the primary energy of natural gas in energy source of the EAF.

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In the analyses which the metallurgical thermodynamics requires regarding the estimates in primary energy, the coefficients e defined above must not confused with the reports for equivalence from physics (860 kcal/kWh, 3.6 MJ/Kwh or 427 kgf.m/Kcal).

For concretization and elucidation, we offer the example below.

At an EAC for steelmaking is registered an electricity consumption of $E_{\hat{\imath}} = 500$ Kwh/t of steel. This means that the deposit of natural gas must provide a quantity of primary energy equal to:

$$E_{\text{p}} = 500.10 = 5000 \quad \text{MJ} \tag{8}$$

Knowing that the calorific value of the natural gas is $H_{i\cdot\text{g.n}} \cong 34 \ \ \text{MJ/m}^3_{\text{N}}$, it results that in order to obtain 1 t of steel in the EAC are consumed at the deposit:

$$m_{\text{cf (g.n)}} = \frac{5000}{34} \cong 147 \quad \text{m}^3_{\text{N}} \times \text{g} \times \text{n/t.otel} \tag{9}$$

If it is intended to measure in conventional fuel, is obtained:

$$m_{\text{p cc}} = \frac{5000}{29} = 172 \quad \text{Kg.c.c/t.otel} \tag{10}$$

In metallurgy, the consumption of natural resources is represented by the consumptions of fuels, energy, raw materials and auxiliary materials.

The consumption of production factors may be analysed both per entire production, in one way or another, named also global consumption, as well as per unit of product or result obtained (a car, a tonne of steel, furniture, an electronic computer, an apartment, etc.).

In regards to the quantitative side of the production factors, entrepreneurs involve them in a different way. So, in the short term, in order to increase production, they resort to hiring more workers and additional raw materials and supplies, in the conditions under which the factor fixed capital remains constant.

In the long term, all production factors are variable, because the increase of production involves changes in all production factors, including the fixed capital (e.g. in order to enhance production, the economic agent may also resort to a new facility of larger size, which can be achieved only in the long term). Of course, quantitative increase of production factors must be accompanied by the pronounced increase of yields that are obtained in their use.

The consumption of production factors has **a dynamic nature,** being different in time, depending on the production volume, the scientific and technical progress, which entails further improvements in the endowment with factors and reducing specific consumption.

Consumption is an economic indicator with a great force of mirroring of the quality of the activity. By reporting the results of consumptions, the efficiency of using the allocated resources may be known. Consumption serves as an underlying criterion for the options and decisions of each producer; in the case where the effects or results of the project variants are identical, the criterion of choosing the optimal variant is represented by the lower level of consumption.

The size of consumption can be seen in one of the following options:

a. per product unit (a tonne of aluminium, a tonne of wheat or of fruit, a cubic meter of methane gas, a machine tool, a car, etc.);

b. per whole production achieved by a company or another and;

c. over a certain period of time.

According to above, the metallurgical economic engineering is to be operated with:

(a) Unitary or specific consumption (S_c), which represents the consumption per product unit or per unit of useful effect (in metallurgy, these are, usually, per tonne of metal material manufactured); it results that S_c is measured in kg fuel; material per tonne of product or J; kWh/t of product.

(b) Global consumption (G_c), which constitutes the consumption corresponding to a given production volume (usually, the production capacity Q, measured in tonnes of product).

The consumption from above may be:

- ***Integrated consumption***, which makes reference to the situation per a whole technological flow.
- ***Partial or sequential consumption***, which describes the integrated consumption per one segment (sequence) from a flow.

(c) Temporal consumption (T_c), which represents the consumption registered in the time unit; can be measured in t, J, kWh/hour, day, month, year.

(d) Marginal consumption (M_c) is given by the supplement (gain) of consumption in order to obtain an additional product unit at a given moment. Being of specific nature, it is determined by relating the growth of global consumption (ΔG_c) to the increase if production (ΔQ):

$$C'm = \Delta C_g / \Delta Q \tag{11}$$

The size of consumption for the whole production (G_c) is dependent on the quantity of products obtained (Q) and unitary consumption (S_c)

$$C'm = f(Q, C_s) \tag{12}$$

The size of consumption per product unit is different, as follows:

a. from one product to another, depending on the specific nature of each, on the consumption of factors which it requires;

b. from one and the same product, from one manufacturer to another, as a result of the endowment with different factors; and

c. at one and the same manufacturer, from a period to another, in dependence on the changes in the technical endowment, in the level of qualification of workers, in the organization and management, etc.

At the flow integrated into the EAC, reducing the electricity consumption is sought to be achieved, mainly, by optimizing the use of renewable energy sources available through technological actions (oxygen blowing through the fireplace, post-combustion, the technology with slag foaming, preheating scrapping, etc.) reducing the waiting time at hot and, respectively, by improving the equipment and conductivity of the thermal and electrical system. The option to supply the EAC in direct current (DC) is accredited with a small reduction of electricity consumption (approximately 5 kWh/t).

Potential resources somewhat higher for reducing fuel consumption will be brought by the third generation of continuous casting plants (CC) namely, by making the blank look somehow like the final steel product. From this point of view, in the industrial advanced phase, with development perspectives, is the thin slab casting, followed closely by the direct taking of hot rolled strip.

The integrated consumption of primary energy shall be calculated at steel mill level in GJ/t crude steel. It has reached an average of about 19.3 GJ/t (about 660 kg cc/t), which for current technologies seems to be the **'minimum technological'.** In the situation where the additional consumption is not taken into account are related to:

- environmental protection;
- age of the main equipment on the steel flow; and
- the deepening of processing in order to increase the share of products with high added-value, the lower limit of the minimum technological should be about 18.2 GJ/t (approximately 620 kg cc/t).

The coefficient of 'energy independence' (E_c) defines the share of the energy taken from the national system and from third parties (like coke, gas, oil products, etc.), which is returned to other consumers from economy. The relation of defining is:

$$C_e = \frac{E_{ic} - E_{oc}}{E_i - E_o} \cdot 100 \qquad (13)$$

In which:
E_{ic} is primary energy from the additional coal and coke purchased from the outside, GJ;

E_{oc} is energy delivered to the outside like coke, breeze coke, by-products of coke plant (tar, oil, etc.), GJ;

E_i is the primary energy from the outside (coal, coke, electricity, oil products, etc.) used in the steelmaking process, GJ;

E_{an} is energy delivered by the steel mill as steam, electricity, fuel gas, GJ.

In the case of steel mills optimized in terms of energy, with appropriate use of their own energy resources, that coefficient has a value of over 100%.

- The achievement of a share of the gross profit rate (GPR) from the exploitation activity (manufacturing):

$$RPB = \frac{P_{rb}}{CA} \times 100 > 13.5\ \% \tag{14}$$

(fuel and energy having a significant share in total costs, therefore influencing the value G_{pr}).

Romania's economy has registered in the period after 2000 recoveries. Thus, if in 2000, GDP per capita of Romania was approximately 33% of that of the Czech Republic, in 2013 gets to be about 41%, therefore a recovery of eight points in the economic offset between the two countries. This fact results also from the level of the average annual growth rate (AAGR) occurring in the period 2000–2013 which in the case of Romania is almost 84% above that of the Czech Republic (3.73%/year against the 2.03%/year).

Quantifying the impact of main sectors in the economy in the GDP is performed by the extent of the **gross value added (GVA).**

In **Table 4**, the evolution of the impact of metallurgy in the GDP is shown.

In **Table 5**, the evolution of performance (GVA) of steelmaking sector (USD^{2010}/t) in some EU states is shown.

In **Table 6**, the impact in the GDP of the two sectors, non-ferrous metallurgy and founding, impact defined in % of the steelmaking sector is shown.

In the context of steelmaking sector, decline in the year of maximum intensity of the crisis, the share of both sectors (non-ferrous and founding) in relation to the steelmaking industry

	2007	2008	2009	2010	2012	2013
France	0.476	0.399	0.210	0.309	0.229	0.234
The United Kingdom	0.376	0.362	0.282	0.256	0.210	0.243
The Czech Republic	1.50	1.167	0.555	0.639	0.660	0.770
Poland	0.97	0.748	0.396	0.452	0.471	0.430
Romania	0.880	0.912	0.152	0.152	0.448	0.344

Table 4. Evolution of the impact of metallurgy in the GDP (% of GDP).

		2000	2007	2008	2009	2010	2012	2013
France	USD^{2010}/t	….	….	341	276	264	190	194
The United Kingdom	USD^{2010}/t	….	….	354	163	248	217	225
The Czech Republic	USD^{2010}/t	….	….	289	165	162	157	204
Poland	USD^{2010}/t	….	….	217	144	168	180	173
Romania	USD^{2010}/t	….	….	268	43	120	182	133

Table 5. The evolution of performance (GVA) of steelmaking sector (USD^{2010}/t) in some EU states.

		2007	2008	2009	2010	2012	2013
France	Non-ferrous	….	35.2	37.5	57.4	60.7	61.1
	Founding	….	34.2	48.6	44.3	48.1	47.8
The United Kingdom	Non-ferrous	….	66.5	156.9	118.4	105.8	93.7
	Founding	….	20.2	45.9	37.7	43.7	34.3
The Czech Republic	Non-ferrous	….	7.2	14.6	18.5	20.8	16.9
	Founding	….	26.9	33.9	34.3	53.9	35.7
Poland	Non-ferrous	….	20.2	34.9	28.4	28.0	30.7
	Founding	….	24.7	42.9	31.9	31.0	40.8
Romania	Non-ferrous	….	17.6	79.8	55.3	27.0	34.9
	Founding	….	5.7	45.0	12.9	10.8	17.2

Table 6. The impact in the GDP of non-ferrous metallurgy and founding, as % of steelmaking.

increases. It is to be noticed that further, after 2009, the share of both sectors in relation to the steelmaking industry, shall be maintained at rates higher than in the pre-crisis phase. This fact proves the usefulness in the GVA of these sectors. Unfortunately, by occult interests, Romania has 'beheaded' many of its production bases for these sectors.

The founding sector (cast iron, steel, non-ferrous) in Romania, in relation to the steelmaking industry, has in the GDP a contribution of less than 50% compared to the contribution of the steelmaking sector. Probably if there were solutions for the maintenance of a larger quota of the strong manufacturing base, existing before 1990—under the conditions of drastic reduction of the steel production—the effect would have been with approximately 15% over the present achievements.

Noting that the non-ferrous sector is now present, mainly, only by the industry of aluminium, whose impact in the GDP—in the circumstances of a significant 'decline' of steel sector in 2009 and 2013—is significantly above the achievements of steelmaking industry in the GVA/t (Euro/t).

Accustomed to the high tonnage of steel production in an economy, in relation to the overall tonnage of non-ferrous metallurgy (metal including alloys of Al; Cu; Zn: Sn; etc.) or castings (cast iron, steel or non-ferrous), the rate of impact in the GDP of the two sectors mentioned (non-ferrous and castings), seems surprising. We consider useful the following explanations:

- The price in the market of laminates from metals/non-ferrous alloys is a few times higher than that of the laminates of steel.
- The cast piece is not only a raw material in the economy but also a finished product that gathers a share of the machine building activity, so it has a price in the market over the material from which it is derived (non-ferrous, cast iron, steel).
- From the data available on the Internet on the total production of cast pieces (**Table 5**), it results that the GVA/t has been in 2008 in the United Kingdom of 1211 Euro/t and in

Romania of 487 Euro/t, compared to the average on the steel industry which has been in the United Kingdom of 192 Euro/t and in Romania of 186 Euro/t.

In the production of aluminium of 2008, GVA level/t—in the United Kingdom—was of 1586 Euro/t and in Romania in the same year, the estimated value of the GVA was of 660 Euro/t.

6. Conclusion

Metallurgy is a component of the processing industry. It provides the necessary materials for the development of industrial activities to cover certain needs of the daily life such as the building machines industry, the civil and industrial constructions, energy industry and of the fuel and energy supply industry, the transport industry (road, sea, air), the defence industry, etc.

Basically, today, life is unthinkable also in the future without the existence of the various products of the metallurgical/steel industry.

Often the confusion is made between the necessity of existence of metallurgical products and the opportunity of manufacturing them in an economy. There are also 'lobbyists' interested in maintaining this confusion.

The global financial and economic crisis has affected also the Romanian economy/steel industry.

The significant decrease of production and associated steel demand has resulted in further reduction of production capacities and of the number of employees.

Increase in imports especially from non-EU countries (Ukraine, Turkey, China, etc.), (e.g. Concrete steel, wire rod, flat coated products, semis, etc.),

Increase in uncontrolled and unpredictable way of energy costs, as a result of implementing energy legislative package—climate change.

Crude steel production in Romania has registered, in 2015, an increase by 4.8% compared to the level of 3.1 million t in 2014. But, sales registered by this sector decreased in 2015 by 5.1%.

Metallurgical sector in Romania has lost, over the past 20 years, over 200,000 places of employment, being one of the most affected areas of activity in our country by the measures implemented as a result of the agreements concluded with the International Monetary Fund (IMF).

Immediately after the Revolution in 1989, approximately 250,000 employees were working in the metallurgical sector in Romania. Following the measures implemented on the basis of agreements concluded with the International Monetary Fund (IMF), metallurgy relies, at present, only on 25,000 professionals. Although it has been privatized for an insignificant amount, of just 50 million dollars, Sidex Galati Steel Plant is nevertheless a happy example, because it still exists under the current name of ArcelorMittal. In most cases, however, metallurgical plants have disappeared completely, being privatized through winding up.

Romania is a part of the second group of countries, from the point of view of the European states most affected by the austerity measures imposed by the IMF.

Austerity measures imposed by the IMF have produced the toughest effects socially in Greece; however Romania is part of the second group of countries, from the point of view of the European states most affected by these economic decisions. In the current context, we need to try and see in what way the civil society organizations may determine a change of attitude of international financial institutions in order to make them more responsible toward citizens.

In 2015, there has been noticed an increase of production capacities in almost all metallurgical sectors. The largest increases in production capacities were registered for electric crude steel (+58.5%), for cast iron and ferro-alloys (+19.6%), for crude steel (+11.1%), for long hot-rolled products (+10.8%), for mixture making (+10.6%), as well as for products obtained by cold-rolling (+10.0%).

Metallurgical sectors in which were registered decreases in production capacities were those for steel used for continuous casting (−11.2%) and products obtained from hot rolled products (−10%).

But from the point of view of using production capacities in 2015, it is noted that in the coke, cast iron and ferro-alloys sectors, capacities are used in a proportion of 96.2%, compared to 96.8% in 2014.

Crude steel production plants are used to 66.6% of the capacity compared to 70.6% in 2014, noting also a slight decrease in both coke, cast iron and ferro-alloys and in the crude steel production plants compared to the previous year.

Investments have increased by almost 70%. In 2050, the total expenses for investments in the metallurgical sector amounted to 337.4 million Lei, increasing, in nominal terms, by 67.9% as compared to 2014.

In 2015, investments in most metallurgical sectors have registered growths, but most of them are directed to: rolling mills with 58.6%, rolling mills for cold rolling strips 27.5%, steelworks with 23.8% and flat products with 20.3%.

In exchange, the expenses for environment protection represented 4.9% of the total investment costs, registering a decrease of 10.3% as compared to 2014, says the NIS.

The power consumption of the equipment and steel plants was of 1605.3 GWh (76.8% of consumption), the quantity of 484.2 GWh (23.2%) being used by the auxiliary facilities and internal services.

Per types of equipment and steel plants, the share of the electricity consumption registered is owned by rolling mills (540.6 GWh, respectively, 33.7%), followed by the steelmaking capacities (447.8 GWh, respectively, 27.9%) and electric furnaces for melting and continuous casting (441.5 GWh, respectively, 27.5% of the power consumption of steelmaking equipment and plants).

The gross consumption of energy in the metallurgical industry in 2015 was of 61,244.5 TJ, increasing by 11.8% as compared to the previous year.

Of this consumption, 52.7% has been used for the preparation of the load for blast furnace, 19.4% for other uses, 11.8% for the production of cast iron, 7.0% for the production of steel and 5.5% for rolling mills.

From the point of view of the fuels used in the metallurgical industry, solid fuels hold in 2015 a share of 52.8% (48% in 2014), gaseous fuels 33.5% (36.7% in 2014), while the electrical energy has registered a share of 12.1% (13.0% in 2014).

Of the total of solid fuels, 33.7% represents the coke, the main fuel used in the metallurgical industry.

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