SPE 111996

Metrics for Economic Evaluation of Innovative Technologies in the Oil Industry

Alberto F. Marsala, Saudi Aramco

This paper was prepared for presentation at the 2008 SPE Intelligent Energy Conference and Exhibition held in Amsterdam, The Netherlands, 25–27 February 2008.

Abstract

Technological innovation is a key factor in an oil company's bottom line.

Not only is it a tool for operational process improvement (cost reduction, production, and reserves increase) but also a driver for the company's relational marketing. The intangible components of technological innovation, if properly evaluated and managed, are key drivers for know-how development, technological leadership, and reputation building.

These are crucial factors for staying in business in a world in which it is essential to demonstrate ability to control complex problems (e.g., exploitation in challenging areas, new energy scenarios, environmental, safety, and social constraints, etc.).

These are key issues vis-à-vis stakeholders, partner companies, producer countries, and the global community. Effective business management and performance improvement require quantitative analysis; in other words: never measured, never improved. This paper presents a methodology for the economic impact valuation of innovative technologies in the upstream oil industry. Both tangible and intangible components of an innovative technology contribute to generate value and thus each of them is to be considered as a very concrete point that requires comprehension, valuation, and management.

Introduction

The objective of this paper is to establish a methodology to determine the value (economic return) of innovative technologies, specifically for the exploration & production (E&P, upstream) sector of an international oil company. A similar approach can be applied for a national oil company, a service company, and for any other corporation, not necessarily restricted to the energy sector; the key idea is identifying the value chain for each individual company, and establishing the impact of technology and innovation on it.

Despite the fact that innovation, and especially technological innovation, is universally recognized as a key factor of success, the economic impact of a specific technological innovation on an oil company's bottom line is not easily or commonly determined. This is true in spite of statistics [Ref. 1] (Figure 1) demonstrating that the innovative behavior of a company may translate into shareholder returns of about 20%.

The proposed approach starts with a methodology analysis and then evaluates the economic returns of innovative technologies applications (referred to as tangible returns), assessing their impact on:

- cost saving
- production increase
- reserves increase[1]

This is done by means of classical methodologies (net present value and internal rate of return), carrying out a differential analysis with respect to the business-as-usual base case (traditional technological approach).

The economic returns associated with the immaterial components of innovative technologies (referred to as intangible returns) are then determined. These include: strategic relevance, proprietary know-how, capability to manage technology and operational problems, reputation, technological leadership, etc.

[1] Other drivers and performance indicators typical of E&P are: value of information, geological risk and uncertainty reduction (e.g. the best definition of the petroleum system), increase in exploration Rate of Success (RoS), reduction of drilling or production downtimes, etc. Ultimately, all of these lead back into the three drivers (cost saving, production increase, reserves increase) for quantifying the economic return of an innovative technology on an oil company's bottom line, in absolute or differential terms with respect to business as usual (standard technologies or currently accepted practices).

A scenario analysis is then used to extrapolate the economic evaluation to the entire life cycle of each individual technology examined.
This approach allows defining a methodology for evaluating and quantifying the economic impact of a technology, as a driver in the overall business of an oil company. The methodology may be applied, with appropriate adjustments, *ex ante*, *in itinere* or *ex post*, i.e. before, during or after a technological innovation project.
An ex-ante evaluation is particularly valuable in portfolio assessment, to select from among investment options in different technologies, and define project management strategies relating to the principal value drivers identified. In-itinere evaluations are important for effectively handling various development options and assessing objective and milestone achievements. On the other hand ex-post evaluations serve both as a metric for evaluating research results, to maximize economic return and as a validation tool for the methodology itself [Ref. 2].

Approach

There are three fundamental key points that contribute to illustrate the particular manner in which technology and technological innovation create value in the upstream petroleum industry.

1. Value allocation

The economic value of a technology is not linked exclusively to the technology itself, but it is related to who owns it and to the context of its applications.
A preliminary but crucial observation is that if we are to correctly pose the question, 'what is the economic value of an innovative technology?' We have to put the question in perspective, 'economic value for whom?'
A technology has no value per se; its value depends on who owns it, who uses it, and the context of its application.
A specific technology, for example, a key device for deep water production, may have high strategic and economic value for an international oil company that has its principal assets and future development prospects in deep water (allowing it to obtain exploration concessions and develop otherwise inaccessible reserves), may have no value for another oil company that operates exclusively onshore and has no plans to enter this new operational arena. If this is true for two oil companies with different business contexts and prospects, then it is all the more so for a services company vs. an oil company.
The methodology illustrated in this paper may be extended to other contexts and other industries, but it is critical that the evaluations and economic calculations be carried out within well-defined business contexts.

2. Tangible and intangible value

The bottom line for an international upstream oil company rests on its ability to stay in business (operate anywhere in the world alone or in partnership with other oil companies) and to optimize its operating processes (cost saving, production, and reserves increase). Similarly for a national oil company, staying in business means obtain and maintain the confidence from its governmental regulatory authorities; this confidence is based on the proved capability to explore, develop, produce, and maximize the benefits from the energy resources the country owns, but most importantly on the confidence that this capability will be a best-in-class even for future challenges.
Unlike in other business sectors, for an international oil E&P company, making profits and staying in business does not depend so much on the sales figures of the company's products (oil and gas are a basic commodity), as on its capability to produce them, i.e. obtain operatorships and partnerships in the most promising parts of the world, to consolidate and increase the company's reserves, production capacity, and ultimately its economic revenues.
Success in this perspective is determined by a series of factors, among which are the company's reputation and its technological, geopolitical, and financial ability to operate in an international context.
From an international oil company's viewpoint, economic value is not created simply by applying the technology and reaping its returns in terms of operating processes. It is also generated by owning the technology and the associated know-how, by having contributed to developing it (even if in partnership with technology leaders or other oil companies), and by the potential for further innovation as the index of the company's ability to address the technological challenges of the future. All these factors contribute significantly to build up the technological reputation. For simplicity's sake we have chosen to differentiate between two distinct components of an innovative technology: its *tangible* and *intangible* components.
Both tangible and intangible components of an innovative technology contribute to generate value and thus each of them is to be considered as a very concrete point that requires comprehension, valuation, and management. The objective of the following paragraphs is to lay out a methodology for evaluating both of these components.
When we speak of economic returns deriving from the tangible components of a technology, we mean those linked solely to its application within the upstream operating processes, producing benefits in terms of cost saving, production increase, and reserves increase. In this respect it makes no difference whether the technology under evaluation is innovative or not, whether it is consistent with the company's current or future core business, developed in-house, protected by patents, whether it depends on proprietary or internal know-how for its effective management and future improvement and whether it contributes to a positive reputation and image of technological leadership in the eyes of other oil companies and

governmental bodies of producing countries. These variables are what we call intangible and they contribute broadly to an oil company's ability to stay in business (business retention and business development[2]).

The term intangible has a broader meaning in the economic and financial world [Ref. 3], where it may refer to company assets other than those currently included in the balance sheet, but which contribute significantly to the creation of value (for example, culture, knowledge, skills, style, corporate core values, strategies, brands, client satisfaction and loyalty, degree of employee empowerment, employee benefits, potential markets, competitive positioning, organizational capital, etc.). These intangible assets have to be quantified, especially in the financial and stock market spheres (Figure 2), to understand the reasons for the gap between the recognized stock market value of a company and the value of its net capital in the balance sheet (practically speaking, to get an idea of the reasons for the success of a company and its potential for future growth beyond what can be inferred from its current cash flows). This is why the International Accounting Standards intends to revise the accounting principles for drawing up consolidated financial statements, especially considering the fact that in many sectors the value assigned to intangibles may be as high as 40% to 60% of the entire value of the company.

The intangible components associated with the innovative technologies we are examining in this work are of particular significance as an asset for a company relative to its staying in business, its capability to exist in the present, and to develop in the future.

Both tangible and intangible components have an impact on a company's bottom line.

It is of critical importance to assess the economic value (impact on the company's bottom line) of an innovative technology to define a strategy to optimize its management, development, application, protection, sharing, selling, etc., and to maximize the company's R&D portfolio. Thus, the answer to the question What is the economic value of an innovative technology? – which is the common thread of this paper – makes sense not as a mere accounting curiosity, but because the quantification of a technology's value is essential for determining its management strategies and maximizing its economic value. In substance, an oil company must understand the economic return of technology drivers in general, and of each single technology in particular, to make sound decisions regarding the amount of human and financial resources (internal or external, in partnership with other oil companies, services companies, universities, etc.) to invest in a given technology and in its field applications.

Evaluating solely the economic returns associated with the tangible component of an innovative technology means considering exclusively the returns associated with the application of the technology (as if the oil company had turned to a service company to carry out R&D and provide a turnkey service fully installed in the field). This approach completely ignores the value of having developed this technology or contributed to its development and thus the value of being able to customize it to suit the company's specific needs, improve it further, and integrate it into internal technical and management processes. It does not take into account the value of having dedicated resources and specific proprietary know-how to establish the most appropriate use of the technology. Above all it overlooks the value of the company's image in terms of expertise, technological leadership (in the eyes of partner oil companies and regulatory authorities of producing countries), cutting edge technology, and the ability to solve complex operational problems.

In recent years it is easier than ever for oil companies to find the same innovative technologies and best operational practices on the service company market. The intangible components of know-how and technological reputation attributed to a major international oil company can turn into a competitive advantage for obtaining oil concessions, operatorships or partnerships, both in the most technologically challenging areas and in those with cost or environmental constraints.

In view of the above, it follows that not all technologies have the same impact on business and, hence, not the same value. By innovative technologies we mean technologies that can bring a significant intangible plus (while the rate of innovation or authorship of a technology has no influence on its tangible component). The three macro indices identified for evaluating the intangible components are:

i strategic relevance (only innovative and original technologies regarding core processes and activities have any relevance)

ii visibility, reputation and partnerships (key factors for business retention and development in the oil business)

iii know-how increase (this is the discriminating factor for sound management of technology and continuous improvement of operational and management practices)

In this framework, a proprietary technology (patents of intellectual properties) can be considered as a value multiplier. The title to patents, in addition to the value associated with the chance of obtaining royalties from sales or licenses (the latter being a rather uncommon practice among oil companies in that it is not considered a core business), contributes mostly to the reputation and image of technological leadership [Ref. 4], as illustrated in Figure 3.

3. Lifecycle value

Value identification has to cover the entire life span of a technology.

To determine the economic return of an innovative technology, the analysis should take into consideration its entire life cycle relative to the company's business. In particular a scenario analysis is necessary, by which the returns calculated for certain

[2] By business retention we mean the company's ability to keep its competitive position; by business development we mean the possibility of enhancing it in the future. Both components contribute to the company's ability to stay in business; hence the technological driver clearly plays an important role in this regard.

specific and representative business cases are then extrapolated to a number of possible applications and to a realistic life cycle.
Similarly, the evaluation of returns on intangibles, even though not strictly related to the number of applications, takes into consideration different *plausible* scenarios and the ability of making a profit from the relevant variables (know-how, intellectual property rights, reputation, etc.).
Obviously, if for strategic or management reasons the number of applications differs (positively or negatively) from that planned, or if value opportunities offered by intangible components are not grasped, the final economic return may significantly differ from that forecast or potential.
This demonstrates again why it is so important to be aware of and clearly determine the value potentials that each innovative technology offers for a company's business.
The goal remains maximizing economic, as well as technical returns, and optimizing management of the technology development strategy.

The economic evaluation

The approach for quantifying the economic value of an innovative technology for an oil company is a combined approach and it is articulated as follows:
First we evaluate the tangible components of a technology on the basis of a number of significant applications.
We then define a scenario encompassing the full technology life cycle, extending the economic evaluations of the identified base case applications to the number of expected future applications relative to the company's assets and operations.
A three step process is then used to evaluate the returns associated with intangible components. The first step is the determination of the value and impact of the overall technological innovation on the company's business (impact on bottom line).
The second involves the use of a scorecard methodology (intangible assessment) to evaluate intangible value components and the relative weights for a specific technology within the company's overall innovation portfolio. Lastly these evaluations are extended to the entire technology life cycle by adding up the cash flows deriving from each component, tangible and intangible.

Tangible components evaluation:

1. As a first step we evaluate the economic returns (cash flows - Figure 4) related to the application of the considered technology to a number of significant applications. A differential approach methodology is applied with respect to the business as usual case. Classical indicators such as Net Present Value (NPV) and Internal Rate of Return (IRR) are calculated. Cost savings, production increase and reserves increase are considered as positive drivers of tangible asset value (positive cash flows). Negative drivers (negative cash flows) are only due to differential costs associated with the technology implementation. R&D costs should not be considered at this stage. A Weighted Average Cost of Capital (WACC) has to be used in all calculations, to normalize the effects of monetary values and inflation over the years.

2. The economic analysis is then extended to the entire technology lifecycle (Figure 5). To determine the economic value of the technology, application scenarios are determined (i.e. defining the number of possible applications that can be carried out during the technology lifetime) and R&D costs are also included in the analyses. It is assumed that each application has the same economic performance as the reference cases identified in the previous step. When it is not possible to define an application scenario, a break even analysis is carried out. The break even point corresponds to the minimum number of applications necessary to balance out the negative (technology development costs) and positive (returns from the applications) cash flows.

Intangible components evaluation:

1. The first step is to define the economic value of the technological lever for the company (in terms of technological leadership, proprietary know-how, etc.). Specifically, we must asses the value of the company's entire upstream innovative technology portfolio as a driver for staying in business (scenarios based on % of E&P revenues or R&D costs) (Figure 6).
To carry out this valuation[3], we can take into consideration three scenarios to assess the impact of the technological innovation on company revenues: for example, equal to R&D expenditures, 3% of company revenues, or 5% of company revenues. The assumed scenarios are particularly conservative, since authoritative sources in the literature [Ref.1], [Ref.5],

[3] A similar approach is used in Marketing for evaluating the impact of an investment in a specific advertising campaign on a company's bottom line. First, this method assesses the overall role and potential of the marketing driver in keeping the company in business (i.e. how marketing and sales can modify a company's competitive position, for example, by increasing its market share). This value is quantified as a percentage of revenues (which may vary according to the industrial sector, potential customers, competitors, etc.) since its impact is ultimately on revenues. Second, in terms of economic impact, the method assesses the role of the specific advertising campaign within the marketing mix, and in particular within the company's promotional actions (portfolio analysis).

and [Ref.6] attribute, in specific sectors, to the technological driver a capacity to create value equal to 20% or even 40% of the company's business volume.

2. The relative percentage contribution of each specific innovative technology is evaluated versus the total intangible value of the company's innovation portfolio by means of the intangible assessment methodology (Figure 7).
This evaluation methodology allows classifying the technologies examined on the basis of their weight in terms of the following three components:

- strategic relevance
- visibility, reputation, and partnerships
- know-how increase

We have determined a series of indicators relative to each of the above three components, to be evaluated on a (1-5) scale for each considered technology (1:minor; 2:low; 3:medium; 4:high; 5:outstanding). The indicators and the relative weight proposed are reported in Table1.
The intangible assessment is therefore a methodology used for classifying the various technologies; the concept is to break down each of the above three intangible components into a series of indicators which, once evaluated and weighted appropriately, attribute a *value* to that component.
Each technology intangible evaluation, based on the three above components, can thus be compared with others using a radar plot (Figure 8). This methodology allows rating the technologies by combining the indicator evaluations of each *intangible value* item.
The critical points of this analytical method are the weighting of the different indicators and the reliability of the evaluations given to each indicator. This process is specific for each individual company, national, international oil or service, industrial sector, etc. The calibration of this process is based on an accurate analysis of the value chain, i.e. the identification of the key drivers that bring value to the company, especially in a business sustainability perspective.

3. The economic value of a specific technology has to be evaluated over its entire life cycle. Considering the intangible components, we could assume that the intangible weight of a technology has zero value at the beginning of the R&D phase, a straight-line increase with the first applications, then reaches and maintains a maximum value for a defined number of years, and finally decreases on a straight-line basis to zero at the end of the life cycle, when the technology becomes obsolete. The assumed distribution of the intangible value of each technology generates therefore a trapezoidal pattern (Figure 9).
Finally, the resulting economic value of a specific technology for its entire life cycle is calculated as the sum of tangible and intangible components as defined in the previous steps (Figure 10).

This approach is termed *combined*, since it combines a classical evaluation system using indicators such as NPV for assessing the tangible returns of a technology with an approach similar to a balanced scorecards method aimed at determining the contribution of a specific technology to the company's intangible assets.
Thanks to this evaluation, ranking the relative weight of each technology can be determined and compared to the company's overall technological portfolio.
The economic quantification of the portfolio within the framework of the company's business hence allows us to assess the role of each technology analyzed in terms of economic value, also considering its intangible components.

Conclusions

What role does technology play in the upstream sector? Is it really a fundamental role? How important is it for oil companies to develop technologies in-house? Do partnerships and collaborations add value to R&D efforts? These questions may seem quite obvious and the answers should surely be positive, but some considerations may be necessary before giving any generic answer. Technological innovation is a key factor in an oil company's bottom line. The methodology illustrated in this paper allows economic impact valuation of innovative technologies in the upstream oil sector. Both tangible and intangible components of an innovative technology contribute to generate value and thus each of them is to be properly valuated. Each industrial sector and business context has its own key value drivers. Accurate comprehension and evaluation of a company's value chain is crucial in the effective management of innovation and R&D activities. The methodology discussed represents a recommended approach by the authors [Ref. 7].

Acknowledgements

This paper is an elaborated extract from the work 'Value of Innovation' [Ref. 7]. Special thanks are due to the authors of the research, the master students, and colleagues who collaborated in this methodological joint effort. The author is grateful for Saudi Aramco's permission to publish this paper.

References

1. Robyn Wye, Accenture: "Managing Turbulent Technology for Exploration and Production Success" paper SPE 77702 presented at the ATCE SPE 2002, Texas – USA
2. Tommaso Dringoli: "La valutazione dei beni immateriali. Le tecniche di valutazione." University of Rome La Sapienza, 2003, Rome- Italy
3. Enzo Baglieri, Vittorio Chiesa, Alberto Grando, Raffaella Manzini: "Evaluating intangible assets: the measurement of R&D performance" in Management of Innovation in the Knowledge Economy-European Perspectives, Nijmegen Business School, SDA Bocconi, 2000, Milano - Italy
4. "Il management degli asset Intangibili - Portafoglio degli asset e creazione del Valore - Valuazione e controllo - Amministrazione e Finanza" - anno XV - Marzo Aprile 2004 - n. 2 - IPSOA Scuola d'Impresa
5. Mark Matthews: "The value of petroleum R&D in Australia." Australian Petroleum Cooperative Research Centre 2001
6. A.D. Little Ltd.: "Wall Street analysts survey, " 2000 - New York - USA
7. Alberto F. Marsala, Nicola De Blasio, Giorgio Vicini, Alberto Di Lullo, Enzo Di Giulio: '*Value of Innovation - methodologies for evaluating the economic impact of innovative technologies in the upstream sector of the petroleum industry*' SPE Italian section, 2005, Milano – Italy (collaboration between a group of Eni Corporate University (Scuola Enrico Mattei) MEDEA Master's students, Eni S.p.A. Exploration & Production Division (Technology Planning), Eni S.p.A (Direzione Tecnica), Fondazione Eni Enrico Mattei and EniTecnologie)

Table 1

VALUE ASSESSMENT FOR INTANGIBLE COMPONENTS OF INNOVATIVE TECHNOLOGIES

		WEIGHTING	
1	**STRATEGIC IMPORTANCE OF THE TECHNOLOGY**	**macroweight 1**	**0.33**
1.1	*RELEVANCE TO STRATEGIC PLAN*	microweight	0.20
1.2	*RELEVANCE TO CURRENT BUSINESS*	microweight	0.30
1.3	*RELEVANCE TO POTENTIAL BUSINESS*	microweight	0.30
1.4	*SYNERGETIC PORTFOLIO EFFECTS*	microweight	0.20
2	**VISIBILITY, REPUTATION, PARTNERSHIPS**	**macroweight 2**	**0.33**
2.1	*PARTNERSHIP QUALITY*	microweight	0.35
2.2	*VISIBILITY*	microweight	0.35
2.3	*HSE and SOCIAL IMAGE*	microweight	0.10
2.4	*LEVEL OF EXCELLENCE*	microweight	0.20
3	**KNOW-HOW INCREASE**	**macroweight 3**	**0.33**
3.1	*LEVEL OF TECHNOLOGICAL INNOVATION*	microweight	0.50
3.2	*CIRCULATION OF INFORMATION*	microweight	0.25
3.3	*CHANGES TO INTERNAL STRUCTURES*	microweight	0.25

Figures

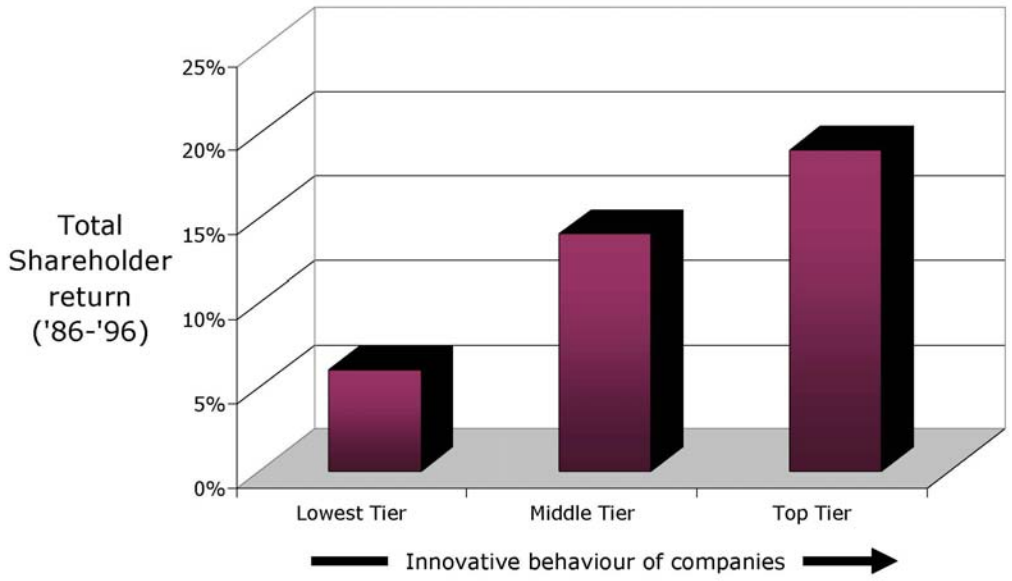

Figure 1: Shareholder returns vs. innovative behavior. (From a survey of Wall Street analysts conducted by A.D. Little Ltd [Ref. 1]).

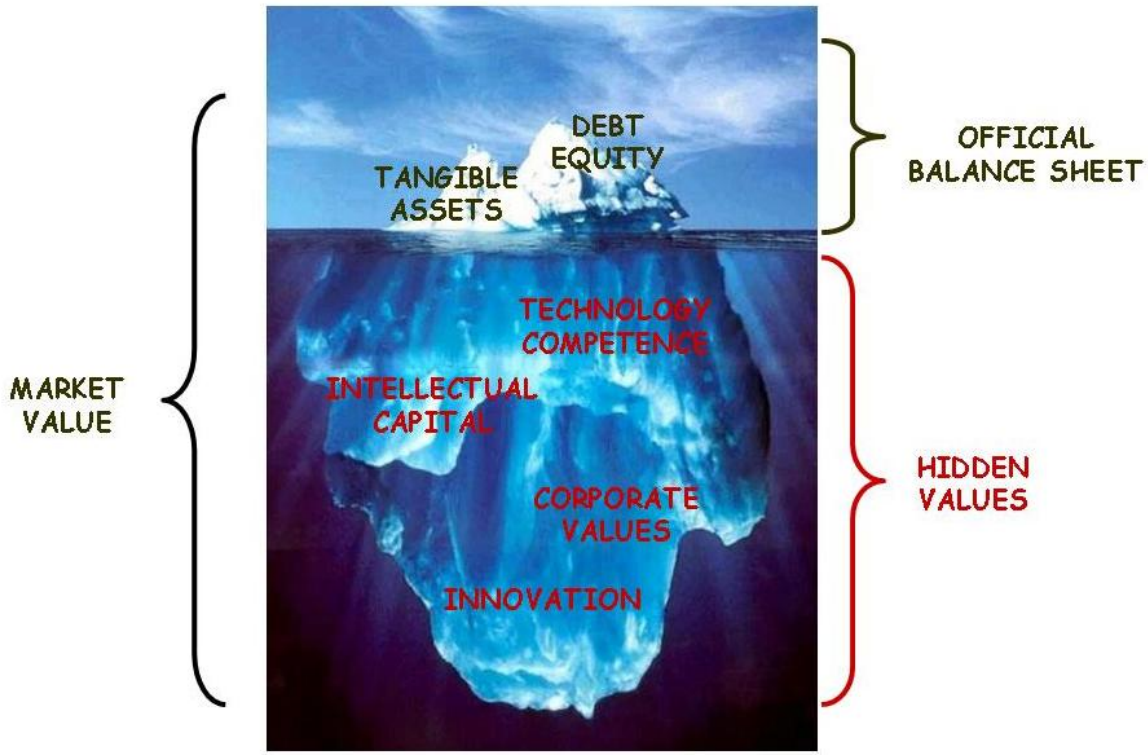

Figure 2 - Intangible assets: Market value. (Source: Andrea Gasperini – AIAF (Italian Association of Financial Analysts)).

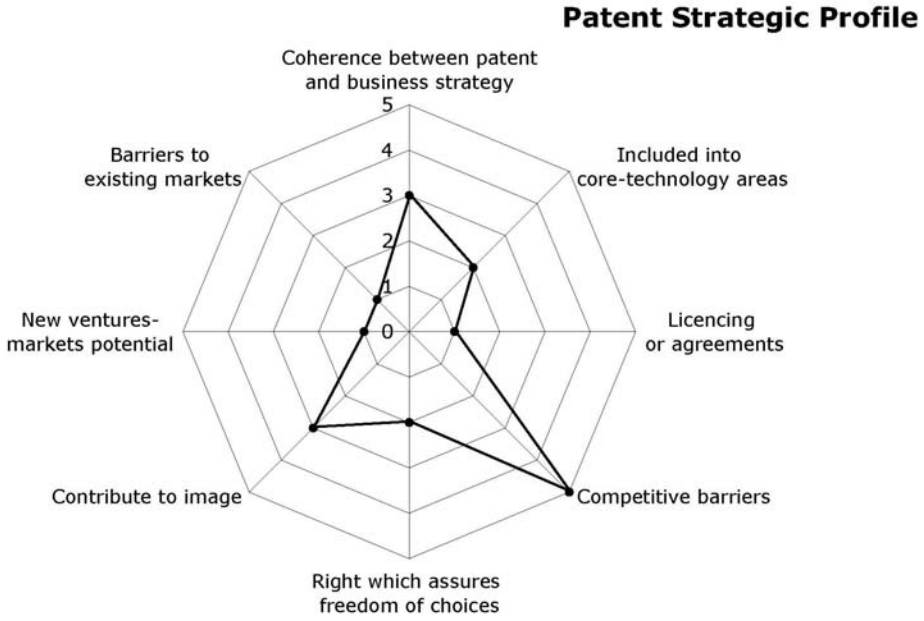

Figure 3 - Strategic components of a patent. (Source: ICM advisors [Ref. 4]).

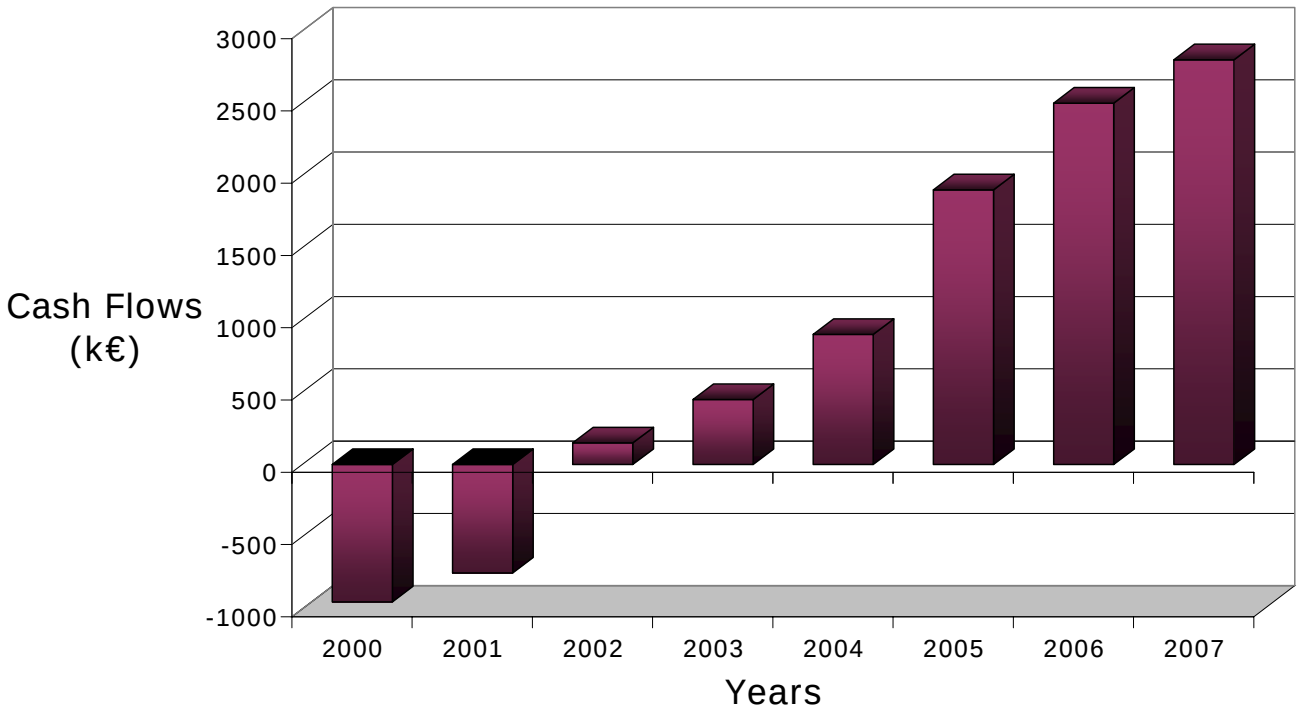

Figure 4 - Net present value of tangible returns, based on cash flows from representative applications of a specific technology. (Example data based on a case study).

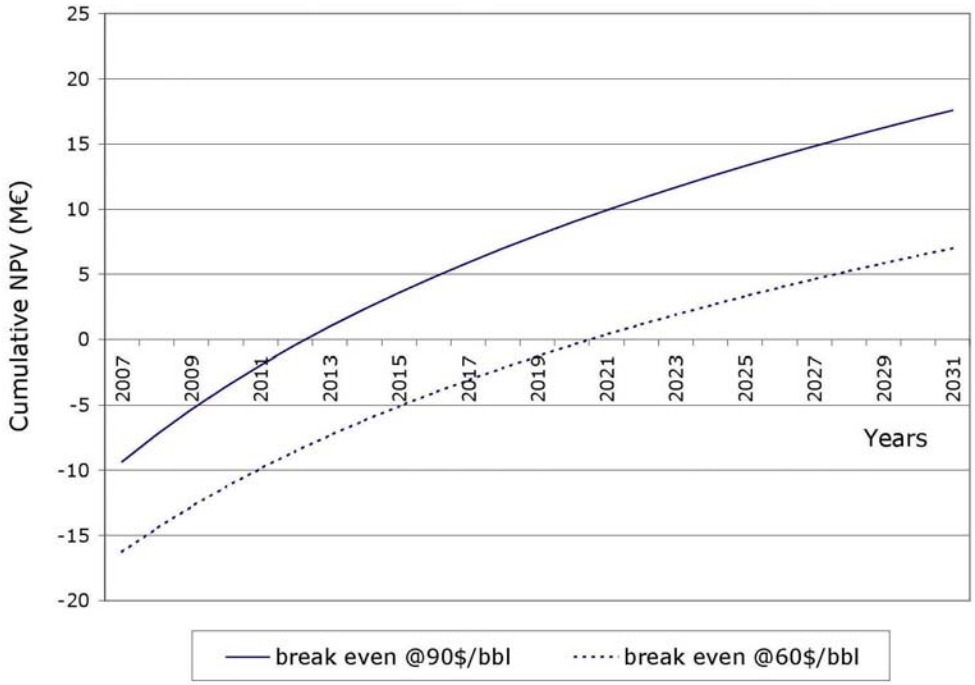

Figure 5 - Valuation of tangibles over the entire life cycle of a technology: scenario analysis and break even points. (Example data based on a case study, relative to two oil barrel price forecasts).

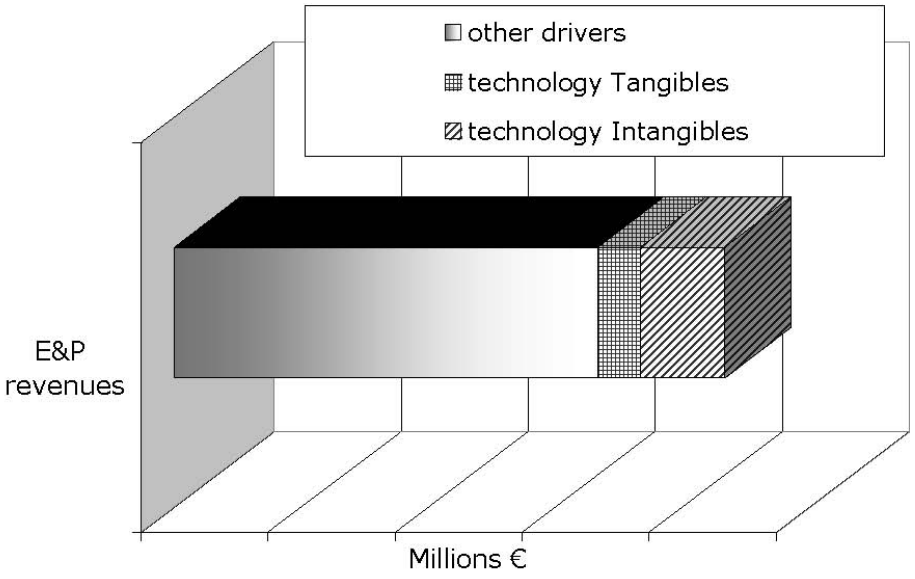

Figure 6 - Estimate of the technological driver's capacity to create value for an oil company. (Example data based on a case study).

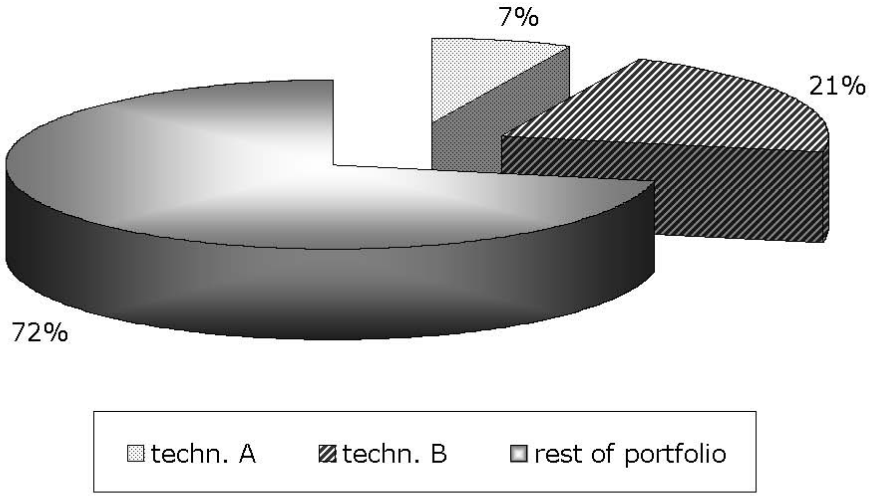

Figure 7 - Intangible assessment: evaluation of the relative percentage contribution of each specific innovative technology to the company's technology portfolio. (Example data based on a case study).

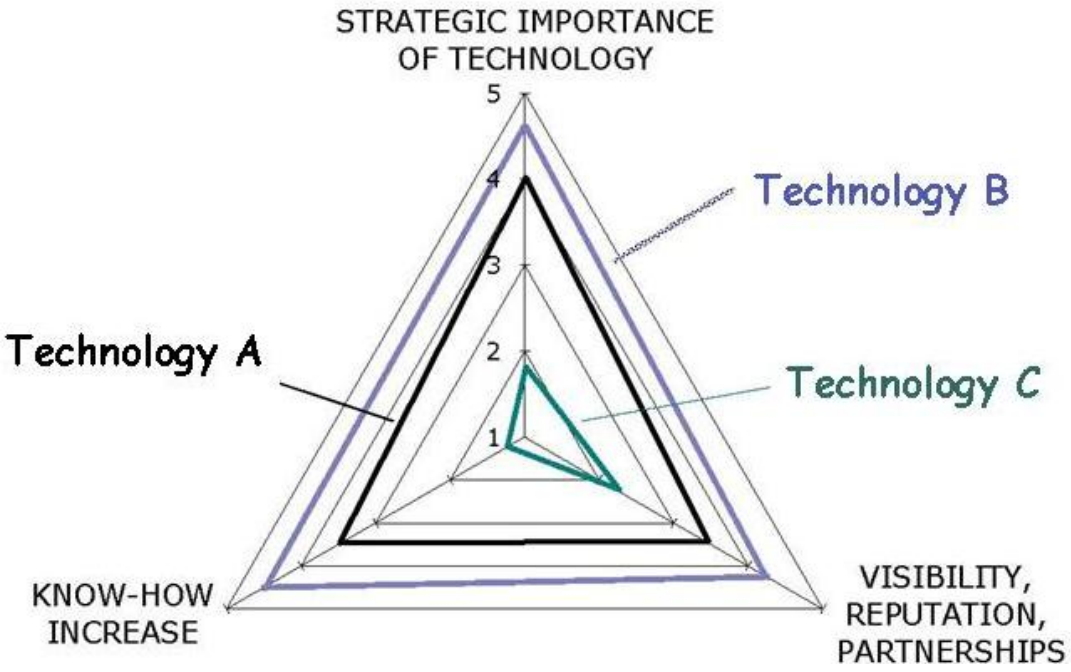

Figure 8 - Radar plot of the intangible assessment of three case study technologies.

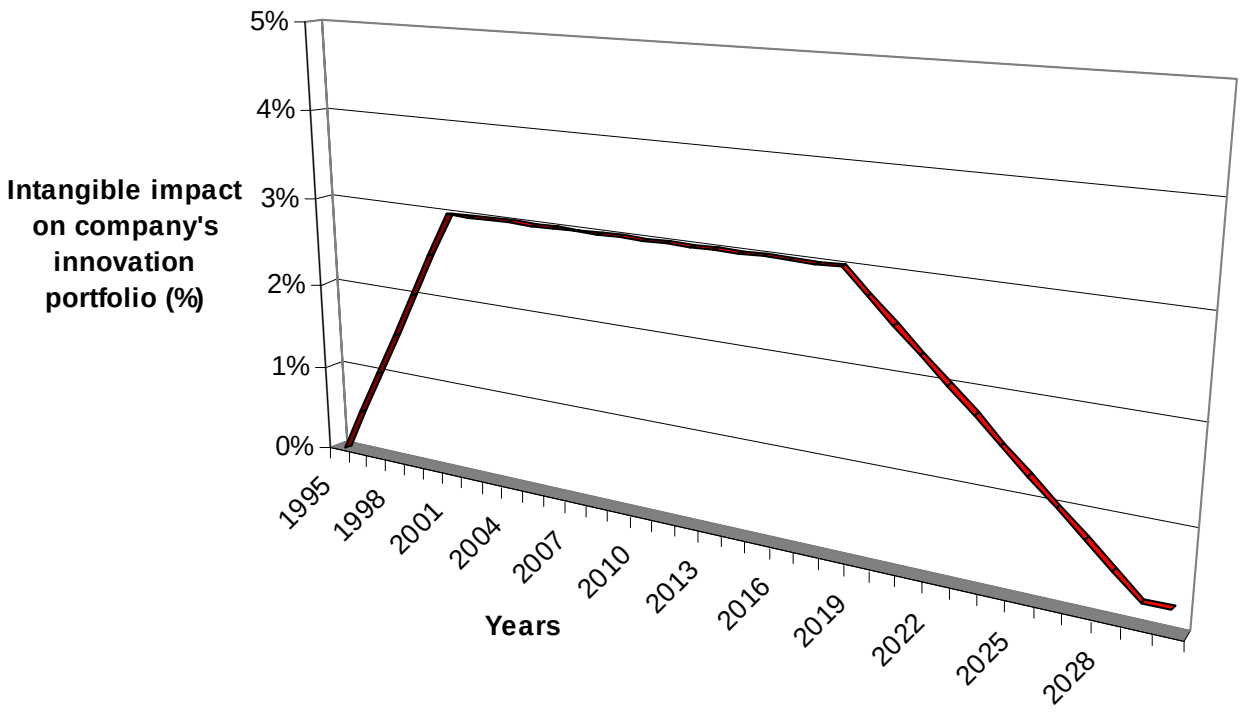

Figure 9 – Intangible value trend for a 40-year-life-cycle technology; the values are % relative to the overall company's innovative technology portfolio. (Example data based on a case study).

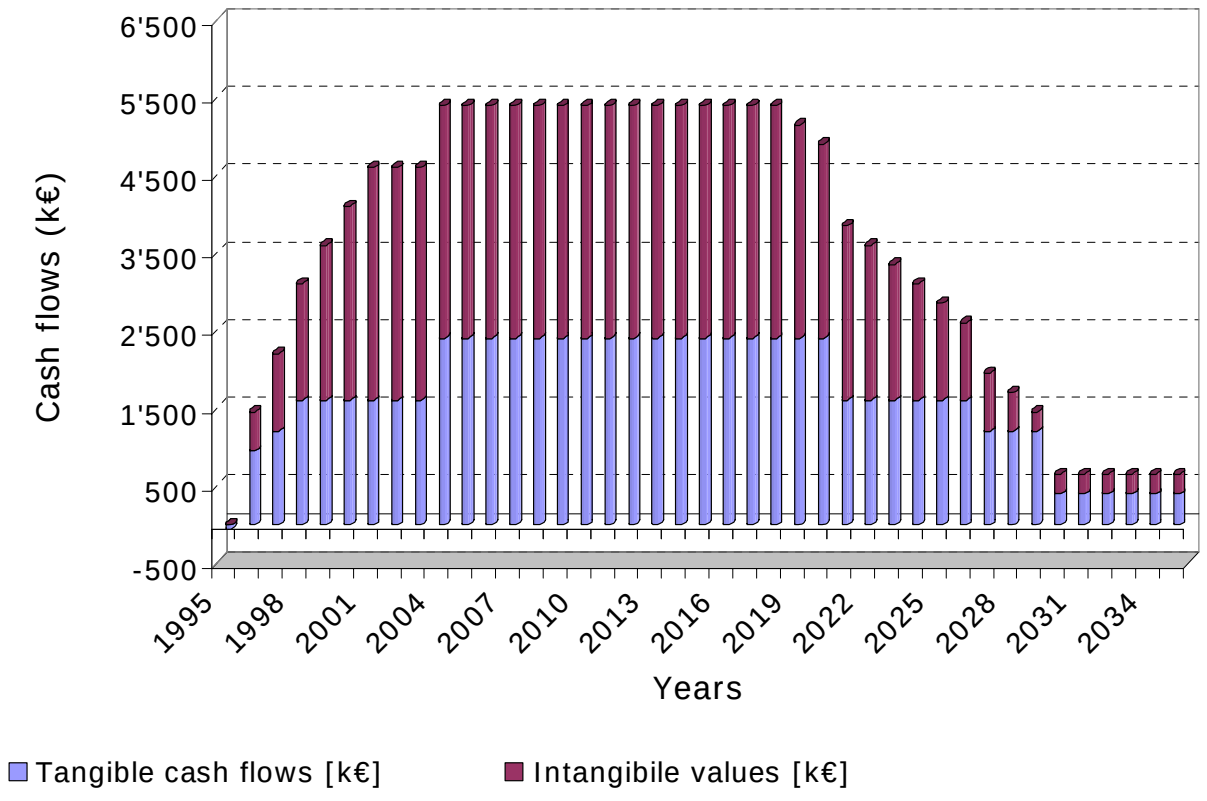

Figure 10 - Tangible and intangible assessment over the entire life cycle of each innovative technology. (Example data based on a case study).