

# Developing Technology Strategy for Consulting Engineers in Water sector

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## Abstract

Nowadays, technology is one of the most important factors in economic and social development. In recent decades, the rapid advancement of technology and its effects of human life have made its importance even more obvious. To continuously expand and improve their business and to achieve a reasonable degree of competitiveness, developing countries need to develop technology strategy. Among the effective factors on lack of attention to technology strategy in those countries, lack of integrated technology platform, having many clients while having a low income, and high costs and lack of capital can be mentioned. Developing technology strategy is the first and most important step for long-term recognition of investment priorities for firms. This research aims to introduce the importance and status of technology strategy and developing procedures and analysis steps and its implementation in the level of consulting engineers (water sector). The obtained results can help business firms to choose the appropriate technology strategy development method.

**Keywords:** Technology; Strategy; Technology assessment; Technology strategy.

## Introduction

Effective development of technology capabilities sector in recent years has been recognized as a way to create a sustainable competitive advantage for firms (Zahra and Covin, 1993). Technology strategies are plans that guide decisions about developing and applying technological capabilities (Zahra, 1996). Spatial and Bickford, recognized technology strategy as a set of strategic choices and necessary measures by executives for transforming inputs into outputs in order to obtain competitive advantage (Spatial and Bickford, 1992).

Also Ford and Saren defined technology strategy as a set of tasks and activities in order to create, protect and utilize technological assets, they view technology as a set of firm's capabilities. This definition suggests that technology strategy is the center of organization, whether this organization is technology-driven or not, is producer or service provider, innovator or follower (Ford and Saren, 2001). Acquiring and effectively applying new technologies is considered one of the fundamental approaches to obtain power, influence and international competitiveness for organizations. Macro strategies for organization such as aggressive, defensive, competitive and conservative strategies have been proposed and are the main leading factor for developing strategies and shaping technology development process (David, 2007).

Currently, the role of technology in creating a competitive advantage has made it a vital and strategically important feature at the level of organization or industry. Increasing constraints on organizational resources, especially in developing countries, has become a major and substantial challenge. Therefore prioritization of planning and development of technology has become more important than ever. This research aims to investigate the effects of developing technology strategy on competitive performance and capabilities of consulting Engineers Corporation in water sector.

## Review of Literature

According to some experts, technology strategy consists of determining the investment priorities in the field of developing technology with regards to macro strategies and long-term objectives of the organization (Khalil, 2000). Other experts consider a wider framework of decisions related to technology strategy and principally define it as the decision that organization make in relation to investment, devel-

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opment and utilization of its product and procedure technology. In this regard, we can refer to Clark 3 ideas upon which in addition to identifying investment priorities, he identified technology strategy and proper method for development and utilization of chosen technologies (Clarke *et al.*, 1995)

In recent years, extensive applications of various technologies have been developed with tremendous amount of speed and diversity, complexity, and pace of changes and technological developments have played a major role in advancement or retardation of organizations, and considering technology strategy in dynamic environments has turned into an essential factor. According to Chiza's theory, dimensions and factors which are related to decision making for technology strategy, are choose, timing, and manner of acquisition of technologies. These decisions must

be considered together and have interactions on each other. According to the perspective, the output of technology strategy is determining organizations long-term technological policy (Chiesa, 2001).

Therefore, developing proper technology strategy to achieve technological advantage in a competitive market is a fundamental necessity. Thus, the subject of this research is can be considered a significant step to achieve macro technology strategy objectives for firms.

### Conceptual Model

According to the characteristics of the firm in question, Hawkes and Mazolov pattern has used as research model. Figure 1, shows the conceptual model used in this research.

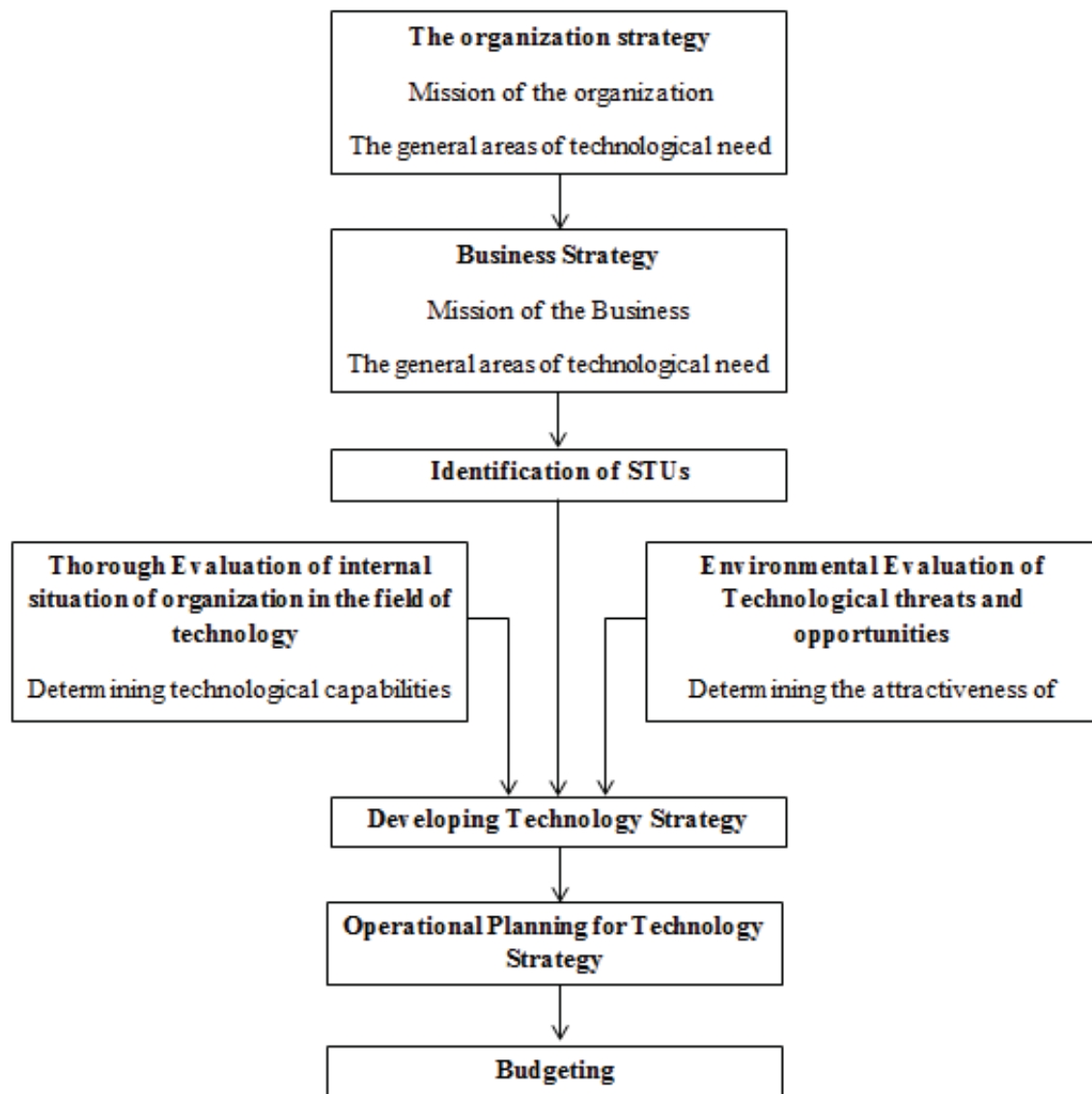


Figure 1. Hawkes and Mazolov pattern for developing technology strategy.

## Research Questions

1. What is the current level of Consulting Engineers Corporation technological (water sector) capabilities?
2. What are the strategic units of Consulting Engineers Corporation (water sector)?
3. How much is the attractiveness of Consulting Engineers Corporation (water sector) technologies?
4. What are the appropriate technology strategies for Consulting Engineers Corporation (water sector)?

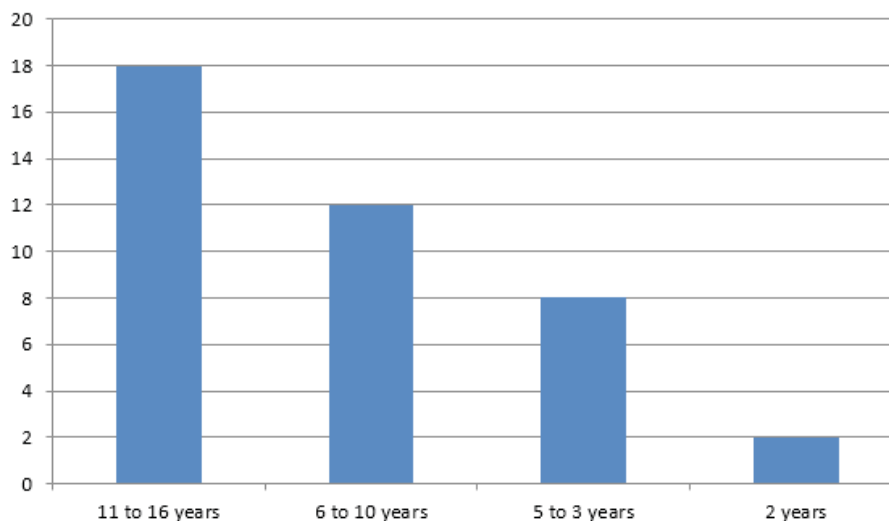
## Materials and Methods

This research is practical in terms of objective and Descriptive - Survey in terms of the implementation method. Field method and questionnaire have been used as means of data collection.

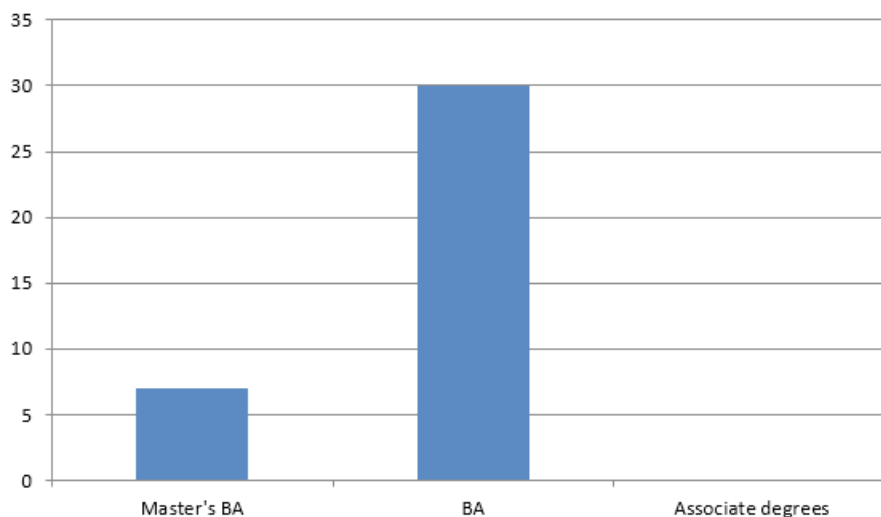
## The Statistical Population

Consulting Engineers Corporation (water sector), provide services in fields of urban and rural water supply network design and designing transmission pipelines, Construction of water reservoir tanks, technical supervision, irrigation , drainage and surveying for engineering and technical services, and currently , relying on the capabilities of its experts an also cooperation with universities, attempts to conduct research projects and gain competitive advantage and also take advantage of the new science and technologies.

Top and intermediate managers of Consulting Engineers Corporation (water sector), possess Associate degrees to Master's Degrees and have more than 2 years of work experience. Diagram 2, shows the work experience and Figure 3 shows education level of statistical population.



**Figure 2. Statistical population work experience.**

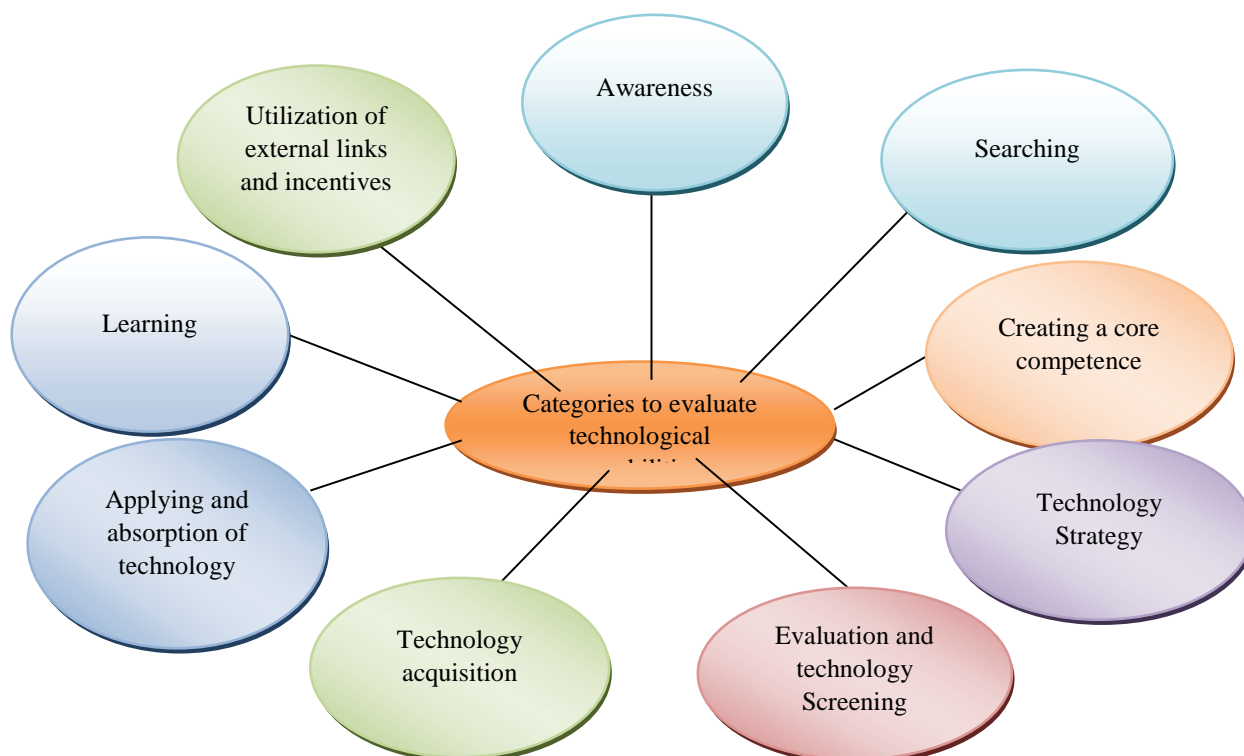


**Figure 3. Statistical population education level.**

### Research steps

1. Evaluation of Consulting Engineers Corporation technological (water sector) capabilities.

Technological needs assessment model have been used to evaluate the corporation capabilities. According to this model, each firm has 9 technological levels (figure 4).



**Figure 4.** Classification of technological capabilities of firms based on technological needs assessment model (Khamseh, 2012).

## Results

### The Results of the First Research Question

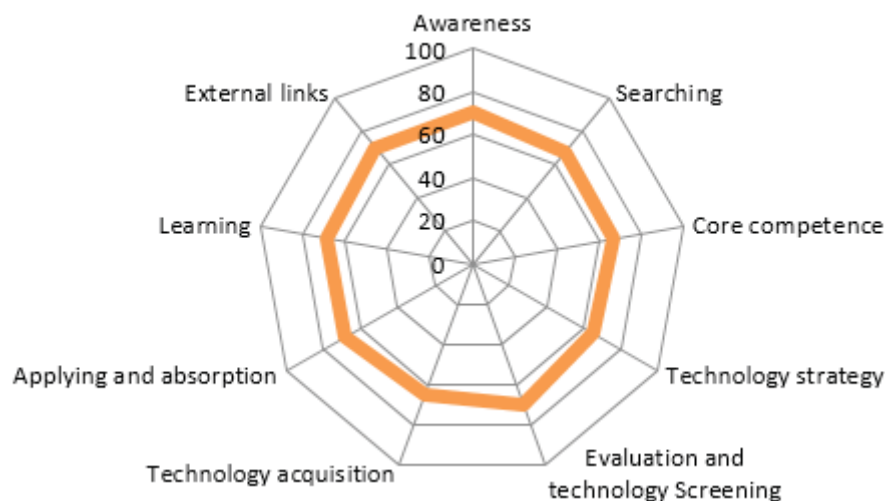
To achieve the result of the first research question, a questionnaire containing 24 questions based on the 9-dimensional model indicators which are shown in figure 1,

was designed. Also the questionnaire was sent to 40 experts. All 40 questionnaires were completed and returned.

According to the results of the questionnaire, table 1 shows average points and firm's technological capabilities. Also, diagram 4 shows firm's capabilities rate and the gap compared to the optimum situation.

**Table 1.** Average points and firm's technological capabilities based on the technological needs assessment model

Dimensions	Number of indicators	Average capabilities (Percent)
Awareness	2	73.33
Searching	2	71.74
Core competence	2	70.76
Technology strategy	3	68.89
Evaluation and technology Screening	2	73.47
Technology acquisition	2	62.29
Applying and absorption	2	68.33
Learning	3	71.53
External links	6	73.84
Average total score	24	70.47



**Figure 5. Radar diagram for Levels of technological capabilities in various aspects.**

As can be seen in figure 5, highest technological capabilities score belongs to external links dimension and lowest score belongs to technology acquisition.

According to the assessment of technological needs model as can be seen in table 2, firms are classified into four groups (Khamseh, 2012).

**Table 2. The form for determining the results of technological needs assessment.**

Partial ranking	Classification of firms	Level of capability	Sum Scores of	The overall audit results
Beginner 1-40 Intermediate 41-80 Pioneer 81-120	Passive (A)	1	1-120	You're firm is weak and inefficient in every important aspect of acquisition and operation, and development of strategy, and needs A major and immediate improvement plan.
Beginner 121-160 Intermediate 161-200 Pioneer 201-240	Reactive (B)	2	121-240	You're firm possesses some weak developments in most of the aspects such as strategy, research, acquisition and capacity building of technology and needs many capabilities to rebuild these areas.
Beginner 241-280 Intermediate 281-320 Pioneer 321-360	Strategic (C)	3	241-360	You're firm is relatively capable in internal capabilities and has a strategic approach to technology, but lags behind national technology in most aspects.
Beginner 361-400 Intermediate 401-440 Pioneer 480-441	Creative (D)	4	361-480	You're firm possesses a fully developed set of technological capabilities and can meet the boundary of national technology, and also has a creative and pioneering approach in some areas and uses technology to gain competitive advantages.

Considering that the total score for Consulting Engineers Corporation (water sector) was calculated 340.83, therefore this corporation will ranked with Strategic Type C, in other words it can be considered a pioneers firm.

#### **Determining strategic technological strategic units**

Strategic technology units are planning tools used to shape strategic answers to strategic needs.

#### **The Results of the Second Research Question**

Given the type of firm's activity selected unit are considered based on effective processes in construc-

tion value chain to determine the strategic technological units. At the macro level project process in Consulting Engineers Corporation (water sector) is shown in figure 4.

Generally, when developing technology strategies, the focus is on the firm's key processes. Therefore, to determine key processes, every sub-process that forms construction of the value chain has to be evaluated by indicators that reflect the goals and strategies of the company.

To this end, each process has been directly evaluated with firm's strategic goals using interviews of managers and experts.



Figure 6. The value chain in Consulting Engineers Corporation (water sector).

Firm's strategic objectives, were determined considering the developed strategies and through manager and related experts. Also, related opportunities and threats for technologies to create competitive advantages and new areas of business were considered in determining these objectives. Determined objectives include:

1. Improving project quality.

2. Using new equipment and technologies.  
3. Increasing efficiency.  
4. Increasing competitiveness in domestic and foreign markets.

Relevance of processes with firm's objectives, were evaluated using matrix method and then their importance is determined, this was done using comments from board of directors and other experts.

Table 3. Results of assessment processes analysis with regards to related objectives.

Total score	Increasing competitiveness in domestic and foreign markets	Increasing efficiency	Using new equipment and technologies	Improving project quality	Objectives	
	40%	25%	15%	20%	Weight of Objectives	Processes
23.75	25	40	5	15	Participation in tenders and contract with the employer	1
13	5	10	30	20	Planning for the implementation of the contract	2
8	5	10	10	10	Providing expert personal	3
23	40	10	10	20	Fulfillment of the obligations and operating	4
22	20	20	20	30	Delivery to Employer	5
9.25	5	10	25	5	Customer Service	6
	100	100	100	100	Total	

As can be seen from obtained results in table 3, the process of participation in tenders and contract with the employer possesses a higher degree of importance than other processes and therefore it is considered as the key process. So, determining strategic technology units identifying technologies are performed with focus on this process.

3. *Determining the attractiveness of the firm's technologies*

Using attractive technology can support and substantially increase competitive position of the firm. Only deep understanding of the qualitative features of technol-

ogies used in the firm can create strategic thinking upon which firm needs for long-term development and gaining competitive advantage can be accurately identified.

### *The Results of the Third Research Question*

To determine attractiveness of technologies, paired comparisons method and AHP hierarchical analysis model were used. The effect of each of the technologies in achieving strategic objectives were determined and attractiveness of specified technologies have been measured after performing required calculations using "Expert choice" software.

AHP questionnaire were designed and answered by related managers and experts and used to obtain attractiveness matrix and based on that information each of the technologies identified in related indices were asked in pairs. Figure 7, shows the AHP hierarchical treeing Consulting Engineers Corporation (water sector).

The obtained questionnaire information was analyzed using “Expert choice” software and at-

tractiveness of technologies were determined. It is worth mentioning that obtained numbers from calculation in the range of zero to one hundred are shown in table 4.

Results obtained about order of preference of the attractiveness of technology are shown in diagram 4, and sensitivity analyses based on the performance are shown in Figure 7.

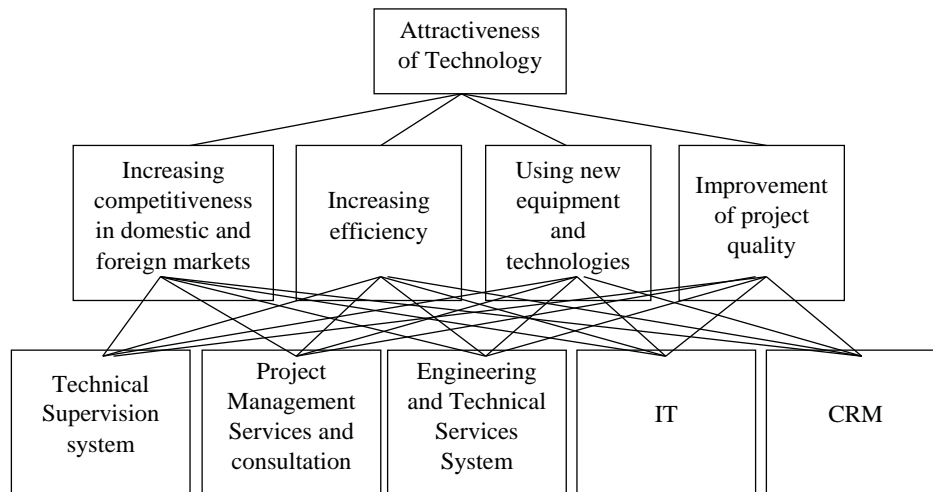


Figure 7. AHP hierarchical tree to determine technologies attractiveness priority.

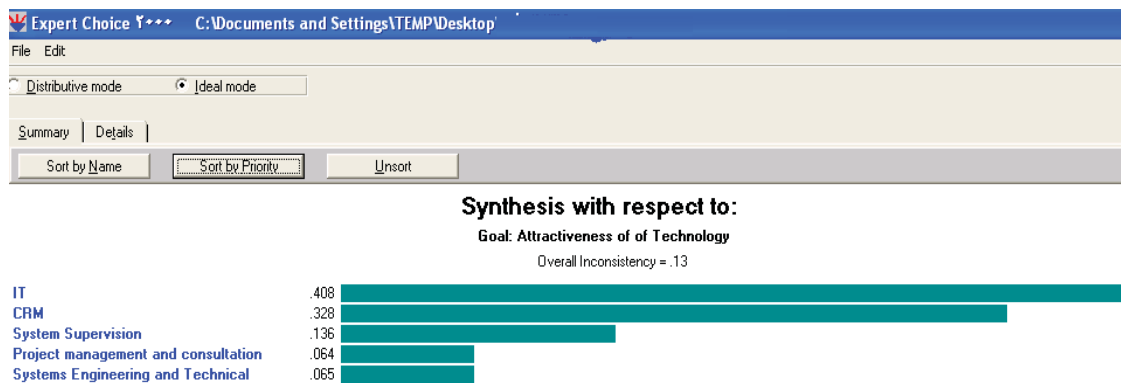


Figure 8. The final prioritization of technological options.

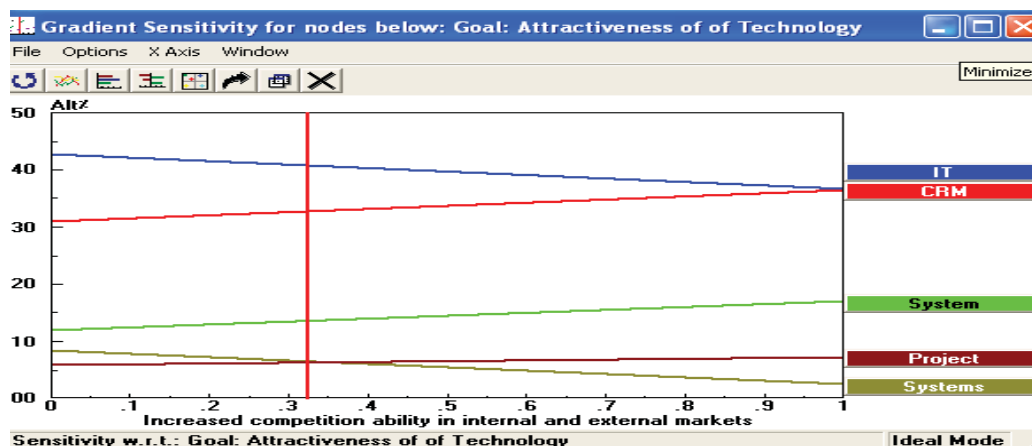


Figure 9. Sensitivity analyses based on the performance about prioritization of technologies attractiveness.

**Table 4. List of technologies attractiveness.**

Attractiveness	Technology	Priority
80.39	CRM	1
100	IT	2
15.93	Systems Engineering and Technical Services	3
15.68	Project management and consultation services	4
33.33	Supervision System	5

### *Determining Appropriate technology strategies for firms*

To determine the technological capability of Consulting Engineers Corporation (water sector) in strategic sectors, “technologic needs assessment” method has been used. The technological capabilities obtained from “technologic needs assessment” method, are classified in 6 groups:

1. The ability to convert (Score: 0 - 10).

2. The ability to sell (Score: 11-30).

3. The ability to obtain (Score: 31-50).

4. The ability to change (Score: 51-67).

5. The ability to design (Score: 68-85).

6. The ability to create (Score: 86-100).

Indices have been presented to managers and experts in form of questionnaire in accordance with table 5 and based on the obtained results, the firm’s technological capability in each strategic sectors have been measured.

**Table 5. Technological capability of Consulting Engineers Corporation (water sector) in strategic sectors**

Percent of Capabilities	Total	The ability to create 86-100	The ability to design 68-85	The ability to change 51-67	The ability to obtain 31-50	The ability to sell 11-30	The ability to convert 0-10	Technology
100	289	98	70	65	35	14	7	CRM
93.77	271	87	72	55	35	18	4	IT
98.26	284	86	78	53	45	20	2	Systems Engineering and Technical Services
91.34	264	87	70	60	32	12	3	Project management and consultation services
95.84	277	88	80	57	35	15	2	Supervision System

After determining the amount of attractiveness of technologies, in order to evaluate firm’s capabilities in these technologies, firm’s technological capability was assessed. Then complexity level was defined for every technology in question to determine the level of firm’s capability. It should be noted that the level of technological capability of Consulting Engineers Corporation (water sector) have been considered and conversion of these levels to a quan-

ties number in a way that it can be used in matrix.

To this end, by creating a common panel of managers and experts and presenting a form to submit their comments about technological capabilities, the level of technological capability were evaluated which can be seen in table 6.

According to table 4 and 5, the capability - attractiveness matrix has been obtained which is shown in Figure 11.

**Table 6. Level of technological capability of Consulting Engineers Corporation (water sector)**

Capability (Percent)	Technology	Rank
100	CRM	2
93.77	IT	1
98.26	Systems Engineering and Technical Services	3
91.34	Project management and consultation services	5
95.84	Supervision System	4



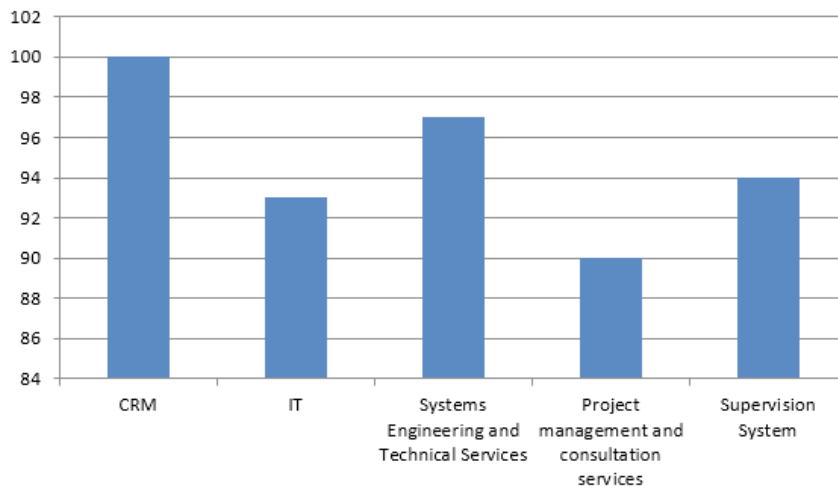


Figure 10. Level of firm's capabilities

Area B (High capability - Low attractiveness) · IT · Project management and consultation services · Supervision System	Area A ( High capability - High attractiveness) · CRM · Systems Engineering and Technical Services
Area D (Low capability - Low attractiveness)	Area C (Low capability - High attractiveness)

Figure 11: The capability - attractiveness matrix.

According to table 7 and also the capability - attractiveness matrix, locating technology in capability - attractiveness matrix for firm's technologies is generated as can be seen in diagram 11.

Table 7. The Summary of ranking of attractiveness and technology capabilities

Capability Number	Attractiveness Number	Technology
100	80.39	CRM
93.77	100	IT
98.26	15.93	Systems Engineering and Technical Services
91.34	15.68	Project management and consultation services
95.84	33.33	Supervision System



Figure 12. Locating Consulting Engineers Corporation (water sector) technologies.

### *The Results of the Fourth Research Question*

Appropriate technology strategies for Consulting Engineers Corporation (water sector) for each area of the matrix are as follows:

Area A technologies: CMR technology and Systems for engineering and technical services are located in area A. According to the level of capability that this firm possesses in this technology and its attractiveness, the following measures are recommended:

1. Maintaining the current status and increasing the amount of CRM capability and systems for engineering and technical services.

Area B technologies: IT and project management and consultation services technologies are located in this area. Due to high capability and low attractiveness in this technology, the following measures are recommended:

2. Due to existence of IT and project management and consultation services technologies which have high capability and low attractiveness, comprehensive planning and goal setting to achieve higher attractiveness is necessary.

Due to uniqueness of required hardware for technologies in this area, the existence of this hardware in the firm is considered a competitive advantage. Therefore, technical knowledge of the technologies has to be transmitted to other firm If possible.

## **Conclusion**

Successful development of a technology depends on available organizations resources and opportunities in the environment. Identifying internal strengths and weaknesses, and external opportunities and threats, is an important step in the process of strategy development.

Strategy, is understanding and planning for the future and is tool that can ease the achievement of long-term objective. The commercial view of strategy is a vast formula that organization adopts in order to achieve success and required plan and scheme to win the competition is fully reflected in it. Developing strategy is an ongoing challenge, therefore, first strategy have to confirm the core of organization's activities and then develop what the organization can do and institutionalized strategic planning activity. This will help them to compete better and strengthen their position in the market.

In this case study Consulting Engineers Corporation (water sector) which is located in rank C (leading strategic); experts have a proper perspective on how to improve the technological capabilities of their firm. Consulting Engineers Corporation (water sector) possesses efficient and innovative experts for new ideas in designing and studying construction projects in water industry and always tried to pro-

vide customer focus, emphasis on quality, continuous productivity, timely delivery, and after delivery services. This firm understands the rapid growth of technology and also identifies targets to determine its effectiveness, and have considered strategic needs of the firm as a fundamental principle, therefore:

1. Competitive advantage for Consulting Engineers Corporation (water sector) in constructional projects is achieved according to attractiveness and technologic capabilities ,

2. Developing proper strategy, with regards to ongoing restrictions of the project in terms of time and resources and also achieving a reasonable and optimal result to ease the process of researching will be very important.

3. Due to the fact that technology strategy is developed for a certain timeframe, it should be investigated and controlled at different time using appropriate mechanisms.

4. Performing technology strategy can save expenses, time reduction of projects, and strengthening the competitive position and help Consulting Engineers (water sector) to develop the proper model based on current objectives and conditions and provide dynamism and evolution in the firm.

Therefore, it is recommended that decision-maker use the best obtained objectives and results in order to achieve consistency in decision-making and determining the appropriate and optimum model.

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