The Key Success Factors for Technology Roadmapping for Emerging Technologies in Energy Sector

Ali Bonyadi Naeeni *, Milad Homayouni Zadeh **, Mohammad Hasan Hemati ***, Kiarash Fartash ****

*Assistant Professor of Progress Engineering, Iran University of Science and Technology, Tehran, Iran.
** Master of Business Administration, Khaje Nasir Toosi University of Technology, Tehran, Iran.
*** Master of Business Administration, Semnan University, Semnan, Iran
**** Phd Student, Management of Technology, Allameh Tabataba’ie University, Tehran, Iran

Abstract

The main purpose of this paper is prioritized the success factor of TRM for emerging technologies in energy sector. In this paper, the literature of TRM has been reviewed thoroughly and by interviewing with experts, five factors have been determined. In order to prioritize these factors a questionnaire has been designed and dispersed. Analysis of result was done during an expert panel, using AHP methodology. Based on the paired comparison of factors, TRM approach is the most important factor and after that, the selection of right people and the commitment from senior management are the important factors to implement TRM.

Keywords: Technology Roadmapping, Key Success factor, Emerging Technologies.

Introduction

Technology roadmap (TRM) has become an important issue and has received increasing interest from academics, industry and business sectors. Its principle use is to provide support in the form of strategic management and long-term planning of technological resources and products or services for future development. Roadmaps support strategic alignment through the creation and use of structured visual representation of the various perspectives needed for successful business and innovation and the process of roadmapping is crucial to achieving this purpose. Researchers almost have studied the concept, adoption, and impacts of the TRMs adopted by a range of industries (Kostoff and Schaller, 2001; Phaal et al., 2004, 2005; Walsh, 2004). The main purpose of this paper is to introduce and prioritize the key success factor for TRM by focus on emerging technologies in energy sector in order to increase the effectiveness and benefits of TRM for these challenging technologies. Emerging technologies because of their complex nature and high risk in investment need more attention for long-term planning and development. This paper is organized as follows. In the next section we define the emerging technologies and review the literature of TRM and the success factors for implementation of this tool.

Literature Review

1. Emerging technologies

Over centuries, innovative methods and new technologies are developed and opened up. Some of these technologies are due to theoretical research, and others from commercial research and development, so according to these technological change especially in technology intensive industries, lack of an effective strategy for companies to manage their technology will challenge the creation and maintaining of competitive advantages over their
competitors (Halluin and Westin, 2004). Emerging technologies are those technical innovations which represent progressive developments within a field for competitive advantage and significant technology developments that broach new territory in some significant way in their field. Examples of currently emerging technologies include information technology, nanotechnology, biotechnology, cognitive science, robotics, and artificial intelligence (O'Reilly Emerging Technology Conference 2008). The energy industry has a vast range of technologies. It involves old-school like oil, gas and coal and new-school sources like solar and wind power. The emerging technologies in this sector with support of national laboratories, industry, and universities in many countries are one of the most important issues for national development. Applying TRM is about to make these technologies more efficient, cost effective, improving research & development planning, and commercialization of them.

2. Technology Roadmap

Recently, technology roadmaps have been actively applied by various organizations such as governments, industries, academic societies and companies (Yasunaga et al., 2006). Technology roadmapping (TRM) is one of the most useful methods that help managers especially who are in technology-intensive industries, to support integrated product-technology planning an how to invest in technologies as the critical capability to gain the maximum benefits and forecast future technological trends that influence the industries (Farrukh et al., 2003; Petrick and Echols, 2004; Phaal et al., 2005; Groenfeld, 2007). The origin of roadmapping is attributed to Motorola that developed the first technology roadmaps in the late 1970s (Willyard and McClees, 1987) and after that other organizations and industry in the world apply this method (Walsh, 2004). TRM is a method for planning technologies to explore future technologies and respond to future market needs (Kostoff and Schaller (2001) and Petrick and Echols (2004)). TRM assess current technologies and core capabilities, projecting these into the future, and evaluate the cost and risk that proposed development strategies and communicate strategies within organizations by updating linked core technologies (McMillan (2003)). TRM by monitoring current technologies and forecasting the future technological trend can develop mid- to long-term technological strategies to create innovation and new opportunities to market growth. Phall and et al (2005) categorized TRMs based on their purpose and format. These category includes eight different types, specifying planning as production planning, capability planning, and so on, with each of the eight formats being characterized in terms of different layers, tables, bars, graphs, and so on.

3. TRM Success Factors

TRM has been applied in a wide variety of industrial contexts, at the company and sector levels an so the publications on TRMs have a significant increase in the amount of literature, however there is still a limited amount of information available on the TRM success factors. According to the definition of a organizational critical success factor (Leidecker and Bruno, 1987), the success factors for a TRM are determined as the limited number of key characteristics and variables that can have a significant impact on the success of a TRM. Experience from practitioners and study the literature of academic researches shows that there are several factors that are particularly crucial for implementation TRM and for better quality of TRM and maximize its benefits, these factors need serious attention (Wells et al. (2004); Phaal and Muller (2009)). A study by Phaal et al. (Phaal t al.,2001) identified some important TRM success factors and keeping the TRM process alive is determined as the most important success factor. Also, Da Costa et al. highlight the clarity with the focus on the information and the relevance to strategies is crucial for success (Da Costa et al.,2005). Gerdsri et al. state some of the key factors for success during initiation, development and integration TRM (Gerdsri et al.,2009). In this section through holistic literature review TRM critical success factor are explained in details:

1) Commitment from senior management

Senior management commitment is required for any initiative to be successful. Simply stated, without their commitment or demonstrated leadership, initiatives stall, fall substantially short of the expectation or just plain fail. Lack of senior management commitment is routinely listed as one of the major risk factors for any projects in organization and so one of the most important factors that influence on TRM (Kappel (2001); Kosto and Schaller (2001), Phaal et al., 2005; McKeen and Smith, 2006). Senior management have several duties that should facilitate the TRM process, such as setting up and serving on a good committee, formulating and establishing good policies and objectives, providing enough resources, overseeing implementation, and evaluating and revising the policy in light of results achieved (McMillan (2003), Elliott (2006), Yamashita et al (2009), Gerdsri et al.,2010).
2) Selecting the right key players

Workshops often form a key element of the roadmapping process, providing an opportunity for participants to share and capture views in a creative environment. The capability and skill of TRM participant also have a great effect on the quality of TRM. In other word, it determines the constraints and boundaries of TRM, so to have a better TRM Interaction with the right people in the workshops and facilitate the right information about technologies, their products and markets, the future of technologies etc (Probert and Shehabuddeen (1999), Wells et al. (2004)). Key players involved in the TRM implementation are idea champions, champion team, TRM operation team and support team, also the engagement from an external consulting team may be necessary, especially in an organization that implements TRM for the first time (Gerdsri et al. (2009)). According to the clear dynamic relationship among skillful teams (market, product, technology, etc), TRM implementation can be strengthened and knowledge can be more effectively shared and transferred and it helps the success TRM implementation (Brown and O'Hare (2001); Elliott (2006) Kostoff et al. (2004)).

3) A suitable TRM approach (Alignment with vision)

TRM efforts are very strategic in nature and often involve forward thinking views of the organization, so one of the important factor that affects TRM is establish an alignment between technological resources and the company’s strategies, as the result this balancing act is critical and challenging for many firms (Lee and Park (2005); Fleury et al. (2006); Cosner et al., 2007; Daim and Oliver, 2008). Organizations should determine the role of technology in fulfilling business vision and should resolve business technological challenges. Organization’s ability to align TRMs and strategies can be measured by how these efforts are incorporated within the development process for roadmaps (Radnor and Peterson, 1999, Gerdsri et al., 2010) and tailoring the scope and boundaries of TRM determine the alignment among organizational strategies and the specific technological processes and their needs and business contexts (Groenveld, 2007, Zweck and Holtmannspor, 2009).

4) Setting TRM process

Roadmap is defined as a technique of communication among stakeholders and key decision makers, roadmapping process is more important than the roadmap itself. Technology roadmapping is principally a group work (Yasunaga et al., 2006). Roadmapping is an iterative and process-oriented approach that needs cross-functional participation including staff from marketing, R&D and operations throughout the process (Cosner et al., 2007, Cho et al., 2009) and on the other hand, the real benefits of TRM often derive from the process of roadmapping rather than the final roadmap outputs (Phaal et al. (2006). So it is important to establish an TRM process which is integrated into technology planning and current processes in organization (Lee et al., 2007, Gerdsri et al., 2009). Through an appropriate method in TRM development processes a number of proposed tools and techniques can be applied in order to articulate both business and technological objectives and merge the TRM process into organization's current business processes (Daim and Oliver, 2008, Gerdsri et al., 2010)

5) TRM software

TRM processes are often executed through workshops or survey methods and this makes it difficult to update roadmaps on a timely or continuous basis (Phaal et al., 2004; Lee and Park, 2005) an so the challenge of maintaining roadmaps hinders the effectiveness of TRM. Organizations should apply techniques to develop software for identification, storage and updating information needed to be used in various fields and layers of TRM (Bruce and Fine, 2004), and as a result software-based roadmapping could help overcome challenges caused by the constraints of roadmapping tools and techniques (Lupini,2002). Table 1 represents the summary of above factors.
Table 1. The Success Factors of Technology Roadmapping

<table>
<thead>
<tr>
<th>Success Factors</th>
<th>Author(s)</th>
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<tbody>
<tr>
<td>Commitment from senior management</td>
<td>Kappel (2001); Kosto and Schaller (2001); Phaal et al. (2005); McKeen and Smith (2006); McMillan (2003); Elliott (2006); Yamashita et al. (2009); Gerdsri et al. (2010)</td>
</tr>
<tr>
<td>Selecting the right key players</td>
<td>Probert and Shehabuddeen (1999); Wells et al. (2004); Gerdsri et al. (2009); Brown and O’Hare (2001); Elliott (2006); Kostoff et al. (2004)</td>
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<td>Setting TRM process</td>
<td>Yasunaga et al. (2006); Cosner et al. (2007); Cho et al. (2009); Phaal et al. (2006); Lee et al. (2007); Gerdsri et al. (2009); Daim and Oliver (2008); Gerdsri et al. (2010); Behestinia et al (2012)</td>
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<tr>
<td>TRM software</td>
<td>Phaal et al. (2004); Lee and Park (2005); Bruce and Fine (2004); Lupini (2002)</td>
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Methodology

Literature shows that, only a limited number of previous researches have analyzed the success factors that influence the use of TRM for emerging technologies. The question of this research is: what are the main success factors of TRM for emerging technologies in energy industry and what is the priority of each? Based on the extensive literature review and interviews with experts, these factors have been determined, and through an expert panel, the validity of the five factors has been verified. In order to prioritize these factors, a questionnaire has been designed and dispersed. During the panel, each factor was discussed thoroughly, then we did one by one comparison based paired method. By the AHP methodology (expert choice software), we defined each factor weight and priority. (Inconsistency index?)

Results

Results show that appropriate approach to TRM is the most important factor in roadmapping success. The other factors weigh and priority, is shown in figure 1.

![Figure 1: Priority of Roadmapping Success Factors](http://www.prj.co.in)

The treeview of TRM success factors can be seen in figure2.
As it can be seen in figure 1, the inconsistency index of comparisons, is below 0.1, so the results are consistent and valid. In order to have clarified understanding of results, figure 3 shows the paired comparison table, after the expert panel.

Discussion & Conclusion

The main purpose of this paper is to prioritize the key success factors of TRM for emerging technologies in the energy context. The findings reveal that TRM approach is the most important factor for emerging technologies in energy sector. It shows that in order to investment and planning for emerging technologies, the alignment of TRM and organization should be concerned. This orchestration determines the priorities of the organization and constructs the layers of roadmap, especially the top layers. The second factor because of analysis is selection of right people and well-staffed team for TRM. The capabilities and competencies of the team who is responsible for TRM are crucial for successful implementation. The reason of this importance is the need of multi disciplinary skills, expertise, and proper idea creation, which TRM needs, and so the team should be well qualified. The third important factor that has been determined is the commitment from senior management. Many authors and researchers have insisted on the importance of top management leadership and commitment in order to design and implement successful TRM. TRM, particularly for its complexity needs strong leadership commitment in order to provide the necessary direction, where an organization will need to effectively implement TRM. Therefore, as the results show without the support and commitment of top-level managers, the success of TRM is cumbersome.
References


