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Innovating problem solving for sustainable green roofs: Potential usage of TRIZ – Theory of inventive problem solving

Muhammad Mansoor[a,b], Norman Mariun[a,*], Noor Izzri AbdulWahab[a]

[a] Centre for Advanced Power and Energy Research (CAPER), Faculty of Engineering, University Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia
[b] Pakistan Institute of Engineering and Technology, Multan, Pakistan

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ABSTRACT

Green roofs are recognized as worthy strategy for making buildings more environmental friendly and sustainable, but there remain a lot of key concerns and limitations in usage of green roofs. Following different driving initiatives for green roofs, researchers are passionately exploring ways to cater deficiencies in existing technologies. The research offered using 'Theory of Inventive Problems Solving (TRIZ)' for seeking further developmental directions and potential future dimensions for green roofs technologies. It presented possible ways to model green roofs related problems with different TRIZ tools, demonstrating ways to seek guidance from TRIZ database of inventive principles and breakthrough solution directions. The research adds value to researchers' working for green roofs in further developments. It provides a way to reach breakthrough solutions beyond one's personal limited knowledge and expertise by broadening the horizon of solution search through TRIZ.

1. Introduction

Green energy, greenhouse gases and go green are well echoed slogans of the last decade. Our planet is getting more urban every day resulting in more buildings and structures of urban settings. It is frequently reported that nearly 40% of energy usage across the world is associated with construction and maintenance of the buildings (Berardi, 2012; Zhou et al., 2014; Hoseini Ghaffarian Hoseini et al., 2013). Globally, buildings are also accountable of almost 33% of greenhouse gases. Since 2008, bigger half of the world population has been living in cities that keep growing faster and faster as the countryside shrinks. This tendency, dosed with some lack of planning, greed, and absence of knowledge or ethics, have already provoked disastrous consequences for Earth, most of them irreversible.

Due to the higher rate of resources and energy consumption by buildings, low energy buildings have been a focus of researchers. Multiple sustainable approaches have been proposed and executed with environmentally responsive energy efficient technologies in this regard (Zhou et al., 2014; Hoseini Ghaffarian Hoseini et al., 2013). These approaches and technologies include energy efficient systems, advanced eco-technologies and renewable sources of energy. In this perspective, Green roofs are recognized as worthy approach for buildings to be more sustainable (Hoseini Ghaffarian Hoseini et al., 2013; Coutts et al., 2013; Zhang et al., 2015). They can add valuable improvements for the said technologies by providing energy conservation, urban agriculture, urban heat Island and biodiversity (Anon, 2016a).

1.1. Green roofs

Green roofs are propagated to have multiple benefits for environment and society naming Urban Heat Island, Biodiversity and Habitat, Energy conservation, Urban Agriculture, Urban Acoustics Improvement, Management of storm water, Air Quality, Job Generation, Aesthetics and Life Quality, Economic Development and Longevity of Life for Roofs (Anon, 2016a).

Because of well discussed and propagated initiative, Green roof technologies development saw a relatively sharp incline in the recent past. Different climates considerations made the researchers work out most suitable custom solutions for each building setting. As a result, green roof technologies got maturity and sophistication over time.

Though the existing technologies show good answer to most of required green roof settings but still their remain some very crucial gaps, which limit/hinder the usage of green roof as primary choice for most of the consumers. The researchers are passionately looking for breakthrough future developments in this area and a lot

* Corresponding author.
E-mail addresses: mansoor.upm@gmail.com, muhammadmansoor@live.com (M. Mansoor), norman@upm.edu.my (N. Mariun).

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of investments by different government/non-government sectors have been involved to improve the existing technologies and maximize the benefits obtained. As cost factors remain a key concern so far, economical barriers of green roofs are usually summarized as (Nicholas Williams et al., 2010; Carter and Keeler, 2008; Peri et al., 2012; Niu et al., 2010; Jim, 2012):

- High construction cost
- High maintenance cost, especially with intensive green roofs or when irrigation is needed
- Complexity of construction
- Risks of failure
- Expensive integration in existing buildings if adjustments to the structure are needed

1.1.1. Challenges and objectives

There is a lot of discussion in research literature on different benefits and challenges for green roof systems. All recent research shows the importance of this technology growth, which is expected to add value to human life and sustainability of eco-system (Coutts et al., 2013; Zhang et al., 2015; Anon, 2016a; Hiu et al., 2010; Tsang and Jim, 2011; Hui, 2006).

To improve comparative benefits and bring about advocated green change, researchers need to answer challenging problems related to usage and acceptance of green roofs. In this high competition of better product development, industry faces a perplexing job while offering its products in the market. Product valuations and comparisons are touching a fast pace for meeting and competing demands of market (Cussler and Moggridge, 2011). The green roofs and related industry (may mainly be taken as engineering industry) working hard to produce economical products and add more values to developed products. This ever growing competition problem is a major thing for current market players to deal with. In current scenario, producers are seeking solutions to achieve low cost product innovation. Hence, high level problems breaking ability is needed for good development and breakthrough design inventions. In existing scenario, industry is showing high deficiency in inventive products, in comparison to the level which is desired and needed by market players (Robles et al., 2009). In this perspective, it is crucial to have strong methods and tools for solution hunters, to meet required innovation level for the competition. To cater issues and limitations discussed for existing problem solving and innovation/creativity methods available for engineers, this research proposes a methodology accompanied by strong tools to support competitive product development. The recommended methodology is known as 'TRIZ: Theory of inventive problem solving' (TRIZ: Russian abbreviation for Teoriya Resheniya Izobreatatelskikh Zadatch) (Rahim et al., 2015).

1.2. TRIZ:A methodology and beyond

"TRIZ" was initially established by "Genrich Altshuller" along with his fellows. Now it has been researched, advanced and used across the globe. A lot of famous multinational organizations use TRIZ on various stages for solving industrial and domestic problems, and also plan for their future technological developments. "TRIZ is not only a methodology, rather it is also a toolset, knowledge-base, and model based technology for developing breakthrough conceptual ideas and practical solutions. TRIZ provides tools and methods for formulating problem, analysis of failure, analysis of system and evolution patterns of system (for 'as-is' and the ones 'could be'). TRIZ, opposite to common known techniques like brainstorming, heuristics etc. (using random ideas generation), aims to construct a systematic approach for development of new systems as well as improvement of existing systems. The innovative solutions are the breakthroughs towards better efficient solutions and better output (Webb., 2002; Petković et al., 2013a, 2013b; Mann, 2002; Mansoor, 2008; Barry et al., 2007; James, 1996; Nisanov, 2004; Bonnema, 2011)". For an engineering system (ES) development, it is a vital plus if the development team had a broad knowledge-base as offered by TRIZ. With TRIZ, solution seekers can generate breakthrough concepts more logically and systematically. TRIZ efficiently addresses conflicting situations, technical-contradictions, need for multiple expertise, reluctance for creativity and psychological-inertia issues in solution seekers via its methodical inventive methods and broad collection of worthy tools. TRIZ increases the understanding and expertise limits of an inventor by providing a verified scientific knowledgebase and helps solution seeker methodically through the procedure of solving innovative problem (Webb., 2002; Petković et al., 2013a; Mann, 2002; Mansoor, 2008; James, 1996; De Carvalho Marco, 2009; Collins, 2006; Ming and Beilei, 2008). The central TRIZ concept that "Technical evolution patterns were repetitive thru different sciences and industries" and also that, "a theory for solutions should be friendly adequately to inventors by using a close to known approach for solving a problem" provides a wider space to search solutions by using TRIZ methods and tools. TRIZ based toolset does assist for exploring scientific solutions as well as expert knowledge space in various dimensions, while requiring lesser proficiency in several fields. Various TRIZ case studies have reported its potential to facilitate engineering education and to develop more skillful engineers (Mansoor, 2008; Filmore, 2008, 2007; Liu et al., 2009; Akay et al., 2008; Chulvi, 2009; Kim, 1993; Low et al., 2001). TRIZ solution approach as compared to traditional trial and error solution approach can be summarized in simple steps shown in Fig. 1.

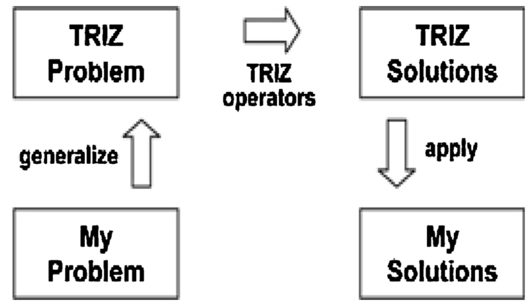

Fig. 1. TRIZ Solution Approach.

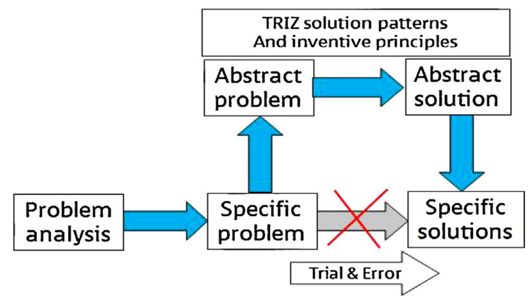

Fig. 2. TRIZ solution approach VS conventional approach (Anon, 2016b).

Figure below (Fig. 2) demonstrates the TRIZ solution approach in comparison to conventional solution approach.

While presenting possible application of TRIZ to engineering disciplines like Chemical engineering, polymer engineering etc. which are close to our intended area of focus i.e. green roofs infrastructures/materials, Rahim et al. proposed a bilateral approach of TRIZ application in the said fields (as shown in Fig. 3). The bilateral model suggested two way possibility to apply innovative solution approach from specific problem to specific solution in case of unknown solutions for a known problem and from specific solution