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Research Article

Future Analysis to Define Guidelines for Wind Energy Production in Iran using Scenario Planning

Mohsen Shafiei Nikabadi [a,*], Elham Ghafari Osmavandani [a], Kasra Dastjani Farahani [b], Amin Hatami [c]

[a] Faculty of Economics, Management and Administration Sciences, Semnan University, Semnan, Iran
[b] Former Member of the Board of Iran Power Development Co.,Tehran, Iran
[c] Farabi College, University of Tehran, Iran

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Abstract

Wind energy production is critical issue as renewable energy sources is continuously increasing over the last decade. The main focus of this study is wind power production which its share is already less than one percent but planned to supply over thirty percent of electricity consumption by 2025. In this study, scenario planning as an increasingly popular method for facilitating multi-criteria decision making and strategic management tool is used. The methodology has been designed in three stages of identifying the critical factors and driving forces affecting wind power industry in Iran, generating plausible scenarios by scenario wizard through cross impact balance analysis and proposing some guidelines for most optimistic, realistic and pessimistic scenarios to eliminate the barriers and promote installed wind power capacity. Considering the score of the scenarios as well as their Impact Score, the scenarios are sorted from most optimistic to most pessimistic. The main contribution of the paper is preparing a realistic view and considering internal and international situations of Iran, local barriers, necessity of attracting foreign investment, know how transfer and technology for manufacturing of turbine over 1 MW, clearly define and analyze the critical factors and driving Forces influencing conceivable futures of wind energy in Iran and propose some guidelines enabling quick respond to forthcoming changes and precise planning to reach desired vision. The results of this research are supposed to developed scenarios provide a detailed review of Iran's long-term wind energy planning and minimize plausible wonders and shocks.

Keywords: Future Analysis, Wind Energy, Scenario Planning, Guideline

Introduction

Progressive awareness of global environmental concerns due to greenhouse gas emissions arising of fossil fuels has been resulted in application of renewable energies to be taken as one of the most essential policies by lots of countries (Chaharsooghi et al., 2015). There have been lots of discussions about the role of renewable energies in resolving some disasters we are facing in future, but the main concern is merely recalling the political will for a consensus of plans and policies enabling the most convenient transition to a global energy system on the

* Corresponding author Email: shafiei@semnan.ac.ir

basis of renewable energies led by wind power (Global Wind Energy Council, 2016). Wind energy has been one of the critical issues in modern grids over the last decade and there has been the focus to have a large amount of electricity from wind energy (Xydis, 2015).

Some countries have set ambitious objectives for the integration of renewable energies specially wind energy into their power systems (Pinson and Girard, 2012; Gosmen and Giebel, 2018). For instance, Denmark with a share of 40% of its power system in 2015, still has ambitious expansion targets of additional off-shore, near-shore and on-shore capacity (Hvelplund et al., 2017) and China has taken a long-term strategy of promoting wind power in order to tackle with its environmental pollution and respond its energy requirement (Zhao et al., 2016). According to Global Wind Energy Council GWEC (2016), global installed capacity of wind energy throughout the world reached 539,581MW by end of 2017 and Turkey in the neighborhood of Iran with 6,857MW installed wind energy has 11th rank in the world (Tavanir, 2016). In Iran, a target of 4.5MW wind energy by 2018 was set in 5th Development Plan and then a mission based on increasing the share of wind power up to 24.5GW by 2025 has been set (Niroo Research Institute, 2016). Although there are different reports about actual wind energy production in Iran, for example, it is said that Iran wind energy is about 140MW out of 75GW total installed power capacity of the country (Wind Energy Quarterly, 2017) which shows the necessity of planning and managing the contracts to develop renewable energies power plants in Iran.

However, in order to achieve the targets for wind energy, Iran would require investments over 60 billion USD by 2025 (Hussein et al., 2016). So the government should facilitate foreign investments on wind energy throughout the country. Although due to the potential of over 16 GW wind energy with economic justification (Niroo Research Institute, 2016), numerous agreements have been concluded for wind farms but too many factors, locally and internationally, are affecting the execution of these agreements. There are some barriers like uncertainty of guaranteed power purchasing contracts and making relevant payments; On the other hand, Iran tend to reduce the Feed-in Tariff same as Germany to ensure private sector that future rates will not be higher than the current rate and this is the best time to invest (Sadeghzadeh, 2015). Also contractors in power industry don't find contentment in the course of guaranteed power purchasing contracts and privatization of power industry; Furthermore, due to considerable debt, the banks are not willing to allocate further credit to this industry (Bargh News, 2016). Still some complications and non-conformities during the process of application for construction license and performing the contracts, have resulted in delay or uncertainty in these projects and due to some delays in custom clearance of required equipment and construction of the plants, they have faced with refusal to extend their licenses or guaranteed power purchasing agreement.

Anyhow, in order to have precise foresee in a dynamic environment under frequent changes, scenarios are credited as an advantageous tool to be prepared for an uncertain future, change mental models, assay the decisions and improve the performance (Chermack et al., 2001). A scenario is a storied description of plausible events or its occurrence during a period of time and scenario planning as an instrument helps decision makers by paving the way for planning, declining uncertainty level and promoting knowledge (Ratcliffe, 2000). Wind Energy production scenarios are increasingly being popular as an input for multi steps decision making; the quality of scenarios has a direct and significant effect on pros of their application in decision making (Pinson and Girard, 2012).

Considering Iran's commitment for 4% reduction of gas emissions by 2030, limited sources for fossil fuel and high pollution by thermal and combined cycle power plants, Iran shall develop renewable energies throughout the country and wind power production sounds inevitable. This study aims that with a realistic point of view and considering internal and international situations of Iran, local barriers (impossibility of local production of turbines with

capacity more than 1 MW, transportation and installation limitations for heavy and big turbines), necessity of attracting foreign investment, know how transfer and technology for manufacturing of turbine over 1MW, clearly define and analyze the critical factors and driving forces influencing conceivable futures of wind energy in Iran and propose some guidelines enabling quick respond to forthcoming changes and precise planning to reach desired vision. The results of this research are supposed to minimize plausible wonders and shocks in the future of Iran wind energy and expanding managers' thought about possible events, facilitate strategic management of energy section of 5th and 6th Development Plan of Iran. This article is organized as follows: Section 2 covers the principal concepts and a brief summary of previous studies, Section 3 describes the research methodology, Section 4 is about results and discussion and the last section is conclusion.

Literature Review

Energy demand is increasing every day and alternative ways for energy production specially wind energy is discussed in recent years (Büyükkeskin et al., 2019). Renewable energy sources like wind energy is a way towards having a sustainable and clean environment in the world and many countries are trying to use their potential of producing electricity from the wind energy (Ghaedi, 2017). Wind energy is about the technology of converting the air motion into mechanical energy usually for electricity production. Wind energy conversion devices can be located in bodies of water (offshore) or in-land (onshore). There are lots of advantages in using wind energy (like low maintenance cost, enormous potential and placement of wind harvesting facilities) that is one of the fastest-growing energy sources in the world even with disadvantage of high initial cost and unpredictability of generated energy (Yousefi et al., 2019). There have been some researches about the wind farms and wind energy in Iran from 2008. One of the best locations of Iran for establishing wind farms is Manjil in the north of Iran (Mostafaeipour and Abarghooei, 2008). Also, there is good potential in Tehran for wind generators for local consumption, battery charging, and water pumping (Keyhani et al., 2010). Iran has offshore wind potential as many countries, but no serious effort is done in this regard (Mostafaeipour, 2010). The wind energy status of Iran in terms of the technological capability in manufacturing wind turbines were evaluated by Bagheri Moghaddam et al. (2011) and resulted that oil-bearing characteristic is the main reason for underdevelopment in using renewable energies in Iran. There have been some other researches in Northern and Southern Khorasan (Saeidi et al., 2011), and Semnan province (Mirhosseini et al., 2011) that showed the potential of using wind energy. Ghaedi (2017) evaluated the wind power in Hormozgan Province of Iran. Ghobadi and Ahmadipari (2018) studied about Selection of suitable sites for wind power plants in Lorestan Province of Iran. Yousefi et al. (2019) studied about impact of wind energy for reducing emissions.

This paper has used scenario planning for facilitating decision making about wind power industry in Iran. According to Lindgren and Bandhold (2003) Scenario Planning is "a consistent internal observation of what the future could be converted". Scenario planning is a qualitative approach in decision making used when main factors are not quantifiable and could not be measured easily and is consisting of uncertainties, processes and opportunities (Alessandri et al., 2004). This method has been applied in different sectors in Iran to determine strategies for: Logistic and Custom services quality (Rayat Pisheh and Tizro, 2016), Energy (Bahrami and Abbaszadeh, 2016), solar energy (Alipour et al., 2019). In the field of future analysis of energy production and consumption, scenario planning has been commonly used in numerous studies. Blomgren et al. (2011) have reviewed scenario planning articles regarding energy market and declares that one segment of interest was future analysis of supply and different energy sources like oil, water, wind, nuclear and bio energy. In 2013 a research was done for 50 scenarios

considering factors like global commitments for reduction of gas emission and competitiveness between renewable energies with fossil and nuclear fuels, ecological concerns, and the level of power consumption in the future energy efficiency. According to the most optimistic scenario, Greenpeace (2012), wind power will gain the first rank amongst renewable energies by 2030. But despite of providing constructive information of global status of this industry, due to environmental differences between Iran and considered countries, it is not practically fruitful for strategic management to achieve the target of getting the first rank in wind power in the Middle East. Charsooghi et al. (2015) through a combination of the changes in energy consumption and renewable energies generation, developed following scenarios: Green Path, Standardization, fossil energy and non-targeted subsidy; whereas in the most optimistic scenario of Green Path, 10% share by renewable energy out of total power production in Iran has been considered to be achievable by 2025. Attaran Kakhaki (2014) also proposed guidelines for renewable energies industry in Iran by scenario planning, but the combination of scenarios was based on leadership/followership by Iran in technological field and economic policies for production of fossil fuel/ renewable energies. Yet according to impressive technological growth of wind power in the world, the hypothesis of becoming leadership by Iran in this industry even in Middle East, with respect to 2025 perspective seems impossible, (see Table1s. in the appendix for previous studies about wind energy in Iran).

Materials and Methods

This research is practical in purpose and in the category of descriptive researches using scenario planning method. The proposed research method comprises three phases:

First phase

- Definition of critical factor: The first step is to define the subject or key decision which has long-term effect; as much as the issue or decision area is restricted, development of scenarios is more facile (Alizadeh et al., 2008). The time horizon for scenarios is generally specified at this step (Miller and Waller., 2003).
- Identification of key factors and drivers: In this step, factors and driving forces which have the highest direct influence on the defined issue are listed (Alizadeh et al., 2008). At this step, extensive literature review has been done based on relevant books, articles and dissertations to extract critical factors and driving forces (see Table 2s. in the appendix).
- Selection of participants: A group of participants that should be selected amongst individuals who are professional in the issues being investigated (Miller and Waller, 2003). Following a judgmental targeted sampling technique besides snowball sampling, 16 professionals were initially contacted via telephone and emails and finally 11 professionals (see Table 3s. in the appendix) participated in this step.
- Identification of critical uncertainties: this step is the ranking of key decision factors and driving forces by the experts' panel on the basis of two criteria: The degree of impact on the pivotal issue or key decision and the degree of uncertainty surrounding those factors or trends.

So attention could be dedicated on high-impact/high-uncertainty factors, for which longer-term planning should be prepared while high-impact/low-uncertainty (see Figure1s. in the appendix) forces providing a relative certain future, for which planning must be prepared (Ratcliffe, 2000). Due to few information about future and growing number of uncertain parameters in the environment, strategic planning for future are very complex (Pishvaee et al., 2008) and there are uncertainty surrounding all factors or trends, also due to uncertainty in some experts opinion and some linguistic experts' evaluation about qualitative judgment scale, the

fuzzy numbers are used as is done in some previous studies for scenario planning like: (Pishvaee et al., 2008; Goker and Dursun, 2019). Critical factors and driving forces have been completed by some supplementary items based on experts' opinion and their impact and uncertainty are ranked under 5-point scale Likert spectrum on the basis of triangular fuzzy numbers. In order to aggregate experts' opinion, the fuzzy average method and defuzzification formula was made on the basis of (Alizadeh et al., 2008), (Habibi et al., 2015).

Second phase

In the second phase, experts evaluate the cross-impact on interdependencies of different states of descriptors defined as critical factors and driving forces identified in phase one, using a qualitative judgment scales as follows for direct influences: strongly restricting influence (-3), strongly promoting influence (+3), moderately restricting influence (-2), moderately promoting influence (+2), weakly restricting influence (-1), weakly promoting influence (+1) and no influence (0). Consequent of all judgments provides an impact network based on which consistent scenarios are calculated by scenario wizard through Cross-Impact Balance (see Table 4s. in the appendix) algorithm (Weimer-Jehle, 2016). For this phase, interviewees detected most important system factors and all available information on the expected future evolution of these descriptors are modified (see Table 5s. in the appendix). Then the set of all judgments defines CIB matrices are fuzzified and then defuzzification is made to define the Impact Network. Loading Analysis Structure and CIB Matrix into scenario wizard, the calculation of the consistent scenarios are made and 10 scenarios are generated (see Figure 2s. in the appendix).

Third Phase

On the third phase, the most optimistic, pessimistic and plausible scenarios are selected out of generated consistent scenarios in phase 2. Then expert panel discusses and proposes some guidelines for these scenarios. Having defined status of each variant of descriptors as Optimistic (O), Moderate (M) or Pessimistic (P), (see Table 6s. in the appendix), the score for each scenario has been assigned. Considering the score of Optimistic, Moderate and Pessimistic states of the scenarios as well as their Impact Score, the scenarios are sorted from most optimistic to most pessimistic scenarios (see Table 7s. in the appendix). Scenario No. 1 as the most optimistic scenario, named “Boom Scenario”, scenario No.6 as the moderate scenario, named “Realistic Scenario” and scenario No.10 as the most pessimistic scenario, named “Desperation Scenario” are selected to be considered by the expert panel in order to propose some strategic guidelines. Then guidelines are ranked by the expert panel from 1 to 5 as the degree of priority subsequently for too low, low, moderate, high, too high and considering the average value, guidelines ranked 4 and 5 are hereby proposed.

Result and Discussions

Scenario No. 1 as the most optimistic scenario, named “Boom Scenario” which is based on the following conditions:

Table 1. Boom Scenario

Investment Cost: Decreased	Continuity of Joint Comprehensive Plan of Action with further evolvement in International collaboration with Iran
Finance: 100% by foreign Investor	
Ex-change Rate: stable	
Guaranteed Period of Purchasing: Stable at 20 years	Willingness and support by government to develop Wind Farm
Feed-in Tariff: Stable	
On time payment for power purchasing	Laws stability and consistency
	Allocated Capital subsidy, grant or rebate

In such scenario, evolvement in international collaboration with Iran would result in decreased investment cost as international insurance companies and financial institute would support foreign investors for wind power projects in Iran that would reduce their costs and risks. Stability in ex-rate, feed-in tariff, guaranteed period of power purchasing, laws and regulations beside the government willingness to support development of wind farms would pave the way to reach the targeted wind power by 2025. Having studied the database from 32 wind farms to explore development patterns to design policies with the aim of optimizing wind farm investments, Enevoldsen et al. (2018) realized that developers are attracted to markets that send clear support signals like market subsidies greater than 10 years in length and have clear procedures established for screening projects and issuing building permits. In this due, following guidelines are proposed to expedite and facilitate wind power development under such circumstances.

Scenario No.6 the moderate scenario or "Realistic Scenario" with the following conditions.

Table 2. Proposed guidelines for Boom Scenario

Establishment of the wind power industry with advanced standards and technologies	(1)
Developing local capabilities for production of wind power components and equipment by making joint-venture and technology transfer contract with advanced International suppliers. Also fiscal incentives like tax or custom duties reduction and convenient and interesting conditions for foreign investors in free zones considering ecological parameters	(2)
Improving the capacity of power grid for wind power: planning wind farm construction, connection system and determine grid-connected load of wind power, increasing the installed capacity of peak load units such as natural gas-fired power plants, pumped storage hydropower or Photovoltaics to raise the peak-shaving capacity of the grid and enhance the grid frequency by regulating and scheduling ability and planning for reduction of losses in distribution lines	(3)
Improving performance of wind system components	(4)
Older small wind turbines to be retired, transformed or reconstructed	(5)
Developing Transport infrastructure to meet the needs of developers. Prioritize new trunk roads, rail links and inland waterways that access development areas. Fast-track remediation of width and height restrictions on truck roads. Encourage investment in specialized port facilities and build investor confidence to foster investment in specialist offshore installation vessels.	(6)
Improving advanced large-capacity turbine system R and D capabilities to meet the needs of the wind power supply chain and ensure wind turbine quality and reliability	(7)
Educating local population on benefits of wind power	(8)
Development of transmission network for trade throughout the country and neighbor countries	(9)
Offshore Wind Power to be started	(10)
Improving more flexible high-voltage DC (HVDC), superconductive and low frequency transmission technologies for large-scale wind farms and long distances.	(11)
Applying smart dispatching techniques for optimal allocation of power resources	(12)
Preferential dispatch must be paired with economic incentives, including the establishment of market-based power pricing and regulations for grid integration and accommodation of largescale wind power	(13)
Plan for and encourage wide geographic distribution of Wind Power Plants	(14)

Table 3. Realistic Scenario

Investment Cost: Increased	Continuity of Joint Comprehensive Plan of Action with current limitations in International collaboration with Iran
Finance: 100% by foreign Investor	
Ex-change Rate: Increased	
Feed-in Tariff: Increased	Unwillingness of Iranian government to support Wind Farm development
Guaranteed Period of Purchasing: decreased to less than 20 years	Laws stability and consistency
Delayed payment for power purchasing	Allocated Capital subsidy, grant or rebate

Current limitations in international collaboration with Iran have resulted in the following barriers for foreign investors. As presented in "Enabling Wind Energy in Iran" conference (2017), despite of interesting market with high potential of wind power in Iran, several items have concerned foreign investors and limited expected development in wind power projects:

- Nomination of Iran by international insurance companies as a country with high risk for investment and no long term reimbursement of credit
- The fear to encounter with danger the contractor's other investments outside of Iran
- The fears about sanctions
- Lack of experience by local banks regarding the finance of power plant projects
- Uncertainty of foreign contractors considering the validity of the letter of credits which is only 6 months and are supposed to be extended accordingly.
- Adjustment of guaranteed power purchasing rate according to the ex-change and inflation rates

In order to promote wind power projects despite all aforesaid concerns, following guidelines are proposed:

Table 4. Proposed guidelines for Realistic Scenario

depending on the distance between power transmission lines and wind farms, subsidies to be awarded to help connect wind farms to the power grid	(1)
Improving performance of wind system components	(2)
Securing reliable supply of key materials or develop alternatives	(3)
Considering capacity payment subsidy to compensate for lost revenue with payments to plants offering flexible capacity for controlled Curtailment	(4)
Removing trade barriers (e.g. removing or reduction of import duties and taxes)	(5)
Encouraging technology exchange with mature wind energy markets	(6)
Encouraging foreign firms to locate manufacturing facilities in the country	(7)
Increasing the deployment of renewable energy across three key sectors: electricity, heat and transport	(8)
Enhancement of wind resource assessment technical standards and technical capability	(9)
Enhancement of overall planning and co-ordination of wind power and other power plants and construction of power grids	(10)
Educating local population on benefits of wind power	(11)
Planning for and encouraging wide geographic distribution of WPPs	(12)
Considering market reform to reward flexibility from different sources in order to encourage fast power plants, demand-side management and response, interconnection and storage	(13)

Dudlák (2018) in his study about Policy challenges in transition to a new political economy of the Iranian oil and gas sectors after partial elimination of sanctions from the beginning of 2016, has proposed some policy recommendations out of which, putting more emphasis on the renewable power sources, creating a predictable environment and consequently minimizing the risks created by political uncertainties.
Scenario No.10 as the most pessimistic scenario, named "Desperation Scenario":

Table 5. Desperation Scenario

Investment Cost: Increased	Delayed payment for power purchasing
Finance: 100% by foreign Investor	Termination of Joint Comprehensive Plan of Action
Ex-change Rate: Increased	Unwillingness of Iranian government to support
Feed-in Tariff: Increased	Wind Farm development
Guaranteed Period of Purchasing: decreased to less than 20 years	Laws non-stability and inconsistency
	Allocated Capital subsidy, grant or rebate

Considering the existing international situations of Iran, the main focus shall be taken on local capabilities. Therefore, following solutions could be proposed to diminish the side effects of forthcoming changes due to sanctions:

Table 6. Proposed guidelines for Desperation Scenario

Supporting domestic manufacturing: additional incentives like tax exemption to promote their production technology and capacity, reduction of custom duty for their raw material and equipment and providing low interest rate loans to the available factories	(1)
Instead of starting new projects, giving first priority to incomplete wind power plants to be completed: compensating part of relevant charges as governmental finance or low interest rate loans to power plant developers, concluding power purchasing agreements with such developers for their operation and sales and granting the first part of such plants with minimum down payment and long term installments	(2)
Considering further incentives (tax reduction or providing low interest rate loans) for Wind Power Plant developers that use locally manufactured equipment	(3)
Considering further incentives for Wind Power Plants owners to increase their capacity and consider extra power purchasing rate for elevated capacity	(4)
Considering extra power purchasing rate for the increased capacity of available Wind Power Plants compared to their average production within last year	(5)
Proposing an incentive package (reduced tax and custom duty, etc) for foreign suppliers which may continue their business in Iran to develop wind power plants or make Joint-venture or technology transfer contracts	(6)
Adjusting power grid management to enhance application of Wind power plant to save fossil fuel and reduce required subsidies	(7)
Granting lands of natural resources keeping and respecting their previous application with convenient conditions	(8)

Conclusion

In this paper scenario planning is used as a strategic management tool for future analysis of Iran's wind energy. At first, with the precise consideration of expert panel, the critical factors and driving forces were eligibly screened to make future scenarios and then some guidelines for most optimistic, realistic and pessimistic scenarios, proposed in order to eliminate the barriers and promote installed wind power capacity. Due to special conditions of Iran,

technology improvements has just been reflected by investment costs for the future of wind power industry and critical factors and driving forces were mainly political and economic. Although forthcoming possible technology improvements in wind turbines capacity and size, advanced monitoring by computer systems and smarter maintenance will evolve wind power industry as is mentioned in Renewables Global Future Report (2013). The total impact and influence of each Critical Factors and Driving Forces calculated with CIB Matrix (see Table 8s. in the appendix) which shows that "Continuity of Joint Comprehensive Plan of Action" as the only descriptor free from influence, has the most impact on the other factors and "Finance" is influenced the most by other descriptors. This result is complying with uptrend in Foreign Direct Investments (FDI) by 64% in 2016 compared with 2015 as remarked by Habibi (2018) government is seeking to attract more FDI with the aim of bringing advanced technology into the country and enhance economic activities and this is supporting the results of our study rating "Political ambitious" with the second highest impact on other descriptors. As per scenario report, the status of continuity of Joint Comprehensive Plan of Action is the only descriptor affecting the ex-change rate and at least one of these two factors are influencing almost all other descriptors.

Optimistic scenarios are based on improvement in the execution of Joint Comprehensive Plan of Action or preceding it despite its limitations during last 2 years but subject to controlling constant ex-change rate. Under such conditions and in case of downtrend in Investment cost arising of technological development in wind power industry or reduction of the risks of investment in Iran, supportive ambitious of the government could pave the way with stability in guaranteed power purchasing price and period with on time payments to the power plant owners as well as stability and consistency in the relevant laws and regulations for foreign investment directly or as a collaboration with local investors. Yet in case the government could not regulate ex-change rate due to arising limitations with sanctions, Investment Cost will increase and the government could not support wind power industry, so the funds for investments will be reduced. It will result in delayed payments to the power plant owners and increased investment costs due to high risk of investment. So it would be necessary to be prepared with supportive guidelines to hold and promote current wind power capacity and expedite the execution of the contracts with European companies. Non-stability and inconsistency in laws and relevant authorizations will lead the future of wind power industry to the most pessimistic scenarios where critical decisions have to be taken. Also according to the findings by Wang and Zou (2018) from previous literatures, the deviation of the policy implementation on a macro-level was generally arising of instability and inconsistency in the policies pertaining to wind power industry. Continuity of Joint Comprehensive Plan of Action have had the most influencing force on the other factors affecting the future of wind power production in Iran. However, most guidelines proposed for Boom and Realistic Scenarios are being supported by some references (see Table 9s. in the appendix). Due to special and different conditions under desperation scenario in Iran, the authors did not find other studies with similarity to be referred, so proposed strategies are supported by expert panel's experience in this market.

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