Evaluating the Performance of Foresight Studies: Evidence from the Egyptian Energy Sector

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Abstract

Foresight projects are expected to provide realistic scenarios for different future scenarios, which provides a better information base for relevant strategies. However, these expectations often turn out to be at least difficult to fulfill due to the uncertainty of the external environment and cognitive biases. Therefore, the idea of assessing each stage of Foresight is gaining relevance, which is of particular importance in the energy sector, which affects a variety of areas of life. This article analyzes the results of the Egyptian energy foresight study, Egypt LEAPS, in terms of process efficiency and forecast accuracy as well as the factors that influenced it, including cognitive biases. The authors conclude that for each stage of foresight, a thorough analysis of weaknesses and shortcomings is necessary. Therefore, from the very beginning, the foresight process should include reliable mechanisms for assessing results and a readiness for constant iterations. Consistent process adjustments that rely on new ways of dealing with complexity and uncertainty in dealing with the future help build trust among participants and consistently reduce the level of erroneous assumptions.

Keywords: foresight assessment; energy foresight; evidence-based policy; energy transition; renewable energy systems; strategies; futures studies; technology foresight; scenario planning; renewable energy; environmental aspects

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Introduction

The topic of assessing technological foresights to improve their quality has become increasingly relevant in recent years. This is due to the increased dynamics of change, as a result of which the influence of factors that determine the quality of forecasts increases many times over, determining the quality of decisions made and the effectiveness of strategies.

Research assessing the results of Foresight projects has intensified only in recent years and is not yet numerous. The assessment is of particular importance for Foresight in the field of energy, since this sector directly affects the socio-economic sphere.

The global energy sector determines the prospects for sustainable development, along with two other basic areas - the environment, the economy, which are constantly considered in Foresights, most often based on scenario planning (Rubio et al., 2023). There are many studies on scenario planning in the field of energy, such as projects by Shell[1], the International Energy Agency (IEA), the International Renewable Energy Development Agency (IRENA), the International Expert Council on Climate Change (IPCC), the European Commission and several other European institutions (Guivarch et al., 2017). They have different coverage - from global trajectories (IPCC, 2014), to energy supply to local areas (Khosala et al., 2021). Horizons typically extend over the long term, for example in the case of the IEA up to 2100 (IEA, 2022).

For example, the European Commission and the Fraunhofer Institute for Systematic and Innovation Research ISI (European Commission, 2016; Fraunhofer ISI, 2014) are working on scenarios for the development of "low-carbon technologies" and renewable energy sources, assessing the prospects for their public acceptance and demand for them. The possibility of a 100% transition to electricity production based on renewable energy sources by 2050 is assessed for 20 European countries and aggregated regions (Hainsh et al., 2022). The Danish Energy Agency is developing "Technology Catalogs" as data for scenarios. They contain the latest knowledge, technology development prospects and forecasts until 2050 (Andersen, Silvast, 2023). As a result, different scenarios compete for influence on the development of the energy system.

Many such projects are currently undergoing evaluation of their results, after which approaches to their implementation are revised in order to increase efficiency.

Egypt's first energy Foresight, Egypt LEAPS, was implemented in 2017 and focused on two horizons: up to 2022 and 2027. In 2022, we attempted to contribute to the accumulation of "evaluative" Foresight work by conducting a similar analysis in connection with reaching the first horizon.

Egypt LEAPS focused on three core energy areas: solar energy, energy efficiency and fossil fuels.

The purpose of our article is to analyze the first large-scale energy Foresight project in Egypt from the point of view of process and effects. The article begins by describing the main trends in the energy transition that set the context for the energy foresight.

Then we will look at the potential of solar energy as the most promising direction for Egypt; forecasts for it turned out to be more accurate. We will also pay attention to the issue of selecting experts, the influence of cognitive biases on the results of the project, and finally present a case study of the project.

Energy transition

With growing concerns about energy security and climate change, the energy transition, which changes the composition of the energy matrix, is a focus for many economies. A special role in this matrix belongs to renewable energy sources (RES), which are considered as drivers for achieving the UN sustainable development goals until 2030. Despite the fact that it is still dominated by non-renewable sources (oil, coal and natural gas) gradually the share of hydro, solar, wind and hydrogen energy, biomass is increasing (Chen et al., 2019), the greatest significance of which was achieved China, USA and Germany and Brazil.

Transition to A sustainable energy matrix requires greater dynamism, large-scale investment in renewable energy infrastructure, overcoming regulatory and political barriers, and managing the social and environmental impacts associated with certain technologies. The energy transition covers a wide range of aspects such as energy technologies, market behavior, environmental impacts and policy development. In order to increase the share of new efficient technologies, it is necessary to study and coordinate energy and environmental policy issues, propose a regulatory framework for designing energy markets, and increase infrastructure investments. The number of similar studies in this direction is growing (Rubio et al., 2023). Many countries are trying to reduce dependence on fossil fuels by moving renewable energy sources to the center of government policy (Galvin, Healy, 2020)[2].

scenario modeling must take into account not only emerging technologies, but also the structural interdependencies between policy development, energy infrastructure expansion, market behavior, environmental impacts and security of supply (del Granado et al., 2018). It is about creating a coherent system

[1] Shell has been developing global scenarios for over 50 years . Examines key trends around the energy transition, prospects for countries, regions and sectors.

[2] See also: https://www.wsj.com/articles/oil-gas-russia-renewable-energy-solar-wind-power-europe-11649086062, accessed 02/12/2024.

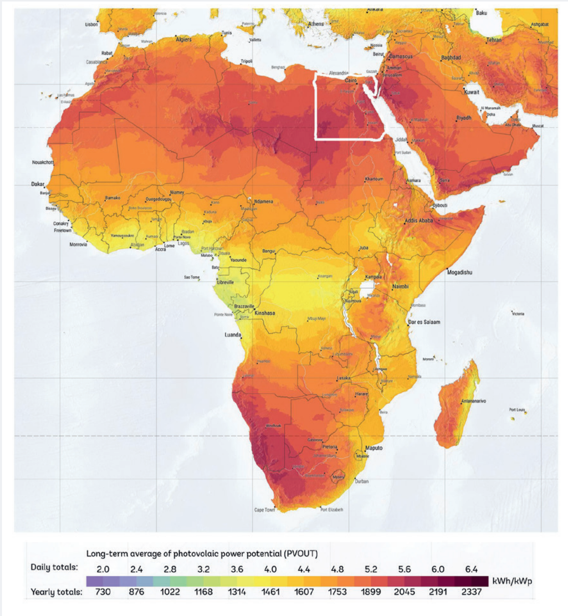
that effectively balances economic, environmental, social costs, risks and benefits (Sareen, Haarstad, 2018). A significant contribution to the development of renewable energy sources was made by solutions in the field of artificial intelligence and other technologies, which made it possible to implement individual projects of integrated energy systems operating on the Smart Grid principle. Despite this, it was not possible to achieve a radical change or reformatting of the energy matrix. The reason is the lack of an integrated model of low-carbon development with clear goals (Luo, Lin, 2023). Its development is hampered by competition between different parties for influence, leadership without commitment, conflicting values and a lack of strategic thinking focused on sustainability (Nwanekezie et al., 2022).

Potential for renewable energy development in Africa

The development of solar energy is of great importance for reformatting the matrix of the energy system in Africa, which has a significant solar resource base (40% of the world's solar energy potential), but is in dire need of technologies for its development (Abdelrazik et al., 2022). Currently, the continent hosts only 1.48% of the world's total solar energy capacity (IRENA, 2021; Huard, Fremaux, 2020).

North Africa, the geographical area to which Egypt belongs due to its ideal location in the Sun Belt region, has an abundance of solar energy, as shown in Fig. 1.

Figure 1. **Distribution of photovoltaic capacity potential for solar energy development in Africa**



Note: The darker the color of the zone, the higher the photovoltaic capacity potential. Egypt (outlined in white on the map) is located in the "darker zones," which means the country has the highest potential for solar energy development.

Source: adapted by the authors on based on : WEF (2022) Africa is leading the way in solar power potential. https://www.weforum.org/agenda/2022/09/africa-solar-power-potential/, date appeals 16.01.2024.

A serious limiting factor to the development of renewable energy sources are financial, personnel, environmental and technological problems (Dagnachew et al., 2020). There is an acute shortage of highly qualified personnel to design, maintain and operate photovoltaic systems. Photovoltaic technologies have not yet become widespread due to the lack of supporting infrastructure. Frequent sandstorms lead to contamination of the surface of solar panels, which reduces their efficiency in converting solar radiation into electricity (Chanchangi et al., 2020; Othman and Hatem, 2022). In Egypt, however, the situation has recently improved due to the entry into the market of KarmSolar, a leading provider of solutions in the field of renewable energy sources that brings together specialists with different competencies. The company was named the nation's fastest-growing player in 2022 and received international recognition by being named one of Fortune's "50 Companies Changing the World" list[3]. Another company, Efika, has become a pioneer in the solar equipment[4] cleaning market.

There are two main types of solar energy technology: photovoltaic energy (directly converts light into electricity), and concentrated solar energy (uses heat reflected from mirrors to drive heat engines). Concentrated photovoltaic cells increase the flux density of sunlight by an average of 200-1000 times with the help of special lenses, hence they are considered the most advanced technologies, since the proportion of solar energy converted into electricity reaches 42%. Based on the high potential of renewable energy sources, Egypt aims to achieve more than 40% of its energy generation from other sources in this category - wind and hydroelectric power plants (IRENA, 2018).

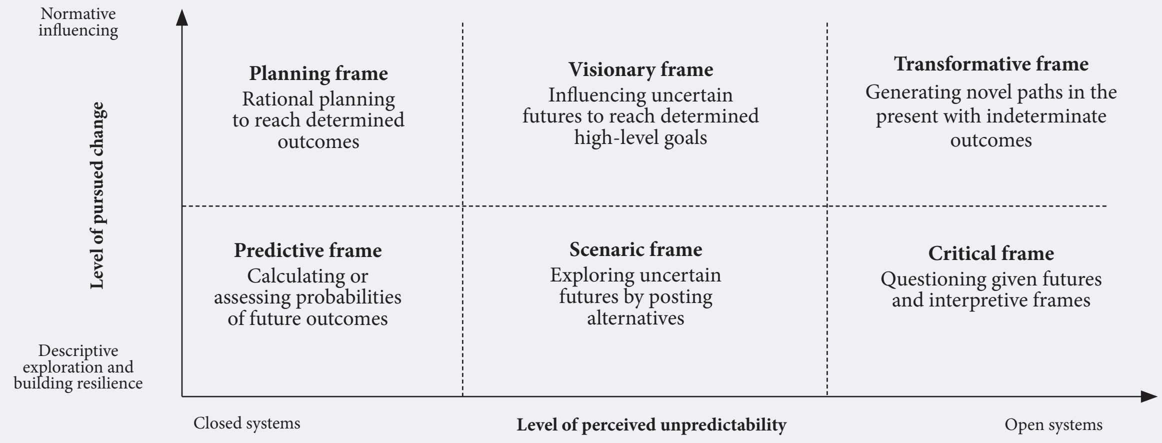
The introduction of new technologies is hampered by the lack of competence among policy makers, project planners and potential users (Havila et al., 2014; Kimuli et al., 2017).

Modern educational programs in Egypt are mostly focused on academic research rather than on the practical aspects of power system design and operation. Only in recent years have educational programs begun to appear that train specialists with a wider range of competencies, including: the design of solar

[3] https://www.karmsolar.com/, accessed 02/15/2024.

[4] https://efika.company/, access date 02/15/2024.

Figure 2. **Matrix of frameworks for implementation and evaluation of Foresight projects**



Source: (Minkkinen et al., 2019).

energy systems, taking into account the latest knowledge and technologies in this area, their maintenance and operation, project management and marketing. Among them are the programs of the Egyptian Youth Academy (Youth Academy Egypt)[5], British University in Egypt (British University in Egypt)[6], Ministry of Electricity and Renewable Energy of Egypt (Ministry of Electricity and Renewable Energy)[7]. The generation of open knowledge transmitted in Foresight project reports makes its contribution.

But not only the lack of competencies affects the "Foresight - strategy - decision-making" connection, but the cognitive biases of experts have a great influence on their content and results, even when competencies are present. Most Foresight participants omit many important aspects, concentrating, as a rule, on only one dimension of future development - reducing the cost of energy. Therefore, forecasts often turn out to be inaccurate due to their attachment to economic estimates of future energy demand (Paltsev, 2017; Stern, 2017; Trutnevyte, 2016; Nemet, 2021), due to their erroneous assumption that current trends will continue, not taking into account the dynamics of change and etc. Therefore, assessing Foresight in various areas becomes a necessary condition for reducing valuable resource losses and forming a more realistic picture of the future.

Evaluation of Foresight projects

The first attempts to evaluate Foresight projects began to be made soon after their activation began in the 1990s, but so far the number of works devoted to their analysis remains insignificant compared to the total body of publications representing the Foresight process itself and its results (Ko, Yang, 2024). Foresight assessments were carried out most actively in Europe and the USA.

Figure 2 presents a classification matrix for the six frameworks of Foresight projects (Minkkinen et al., 2019). Most evaluation methodologies used in corporate practice and academia are based on only two of them: measuring the accuracy of forecasts and the degree of achievement of planned outcomes (Bonaccorsi et al., 2020). This is due to the fact that forecasting and planning deal with low levels of unpredictability. Accordingly, other areas (visionary, scenario, transformational, critical analysis) are reflected to a lesser extent, as they belong to a zone of higher uncertainty and are more difficult to assess (Cuhls, 2003).

Most often, results are assessed based on three criteria: transparency (proper use of public funds to achieve the main goal), validity (reasons for continuing Foresight), lessons learned (methods for the most effective implementation are proposed) (Georghiou, Keenan, 2006). The biggest challenge is transparency, which requires organizing the complex manifold goals, interests and experiences of different project participants. Falsity increases due to need to apply The same unified tests apply to the assessment of Foresight projects as to other ones state programs. The "lessons learned" criterion appeared later on the Foresight assessment agenda, and its role in this process has so far received less attention. Mean-

[5] https://www.pdf-eg.com/node/75, accessed 02/07/2024

[6] https://new.bue.edu.eg/research-centers/center-for-renewable-energy-cre-bue, accessed 02/08/2024.

[7] http://nrea.gov.eg/test/en/About/Tranning, access date 02/08/2024.

while, this aspect is of great value, since it connects current problems with future ones, which increases confidence in Foresight (van der Steen, van der Duin, 2012). Giving it greater significance is constrained by the fact that going beyond "traditional values" is not easy for stakeholders in cognitive terms.

One of the Foresight projects, the results of which are assessed as very successful, is the initiative of the Institute of Advanced Science and Technology (KAIST) of South Korea - "Forecasting and analysis of medium- and long-term future conflicts in order to prevent them" in 2019. It formed the basis of the national development strategy published in 2021.[8] The goal was to integrate Foresight into policy development by proactively analyzing the foundations for future conflicts. As of 2016, Korea ranked third in terms of conflict among the 34 OECD member states (Heo, Seo, 2021). Participants were aware of the existing gap between "knowing" the future and acting towards it in policy making (Riedy, 2009; van der Steen, van Twist, 2013; van Dorser et al., 2020). The lack of "hard evidence", fallibility, and the problematic nature of a legitimate policy source contribute to the separation of Foresight from policy development (Riedy, 2009; van der Steen, van Twist, 2013). Understanding the how and why of stakeholders conceptualize problems or strategies can increase decision makers' openness to new ideas and Foresight concepts (van der Steen, van Twist, 2013).

Indirectly, the project was also designed to build management capacity to make informed decisions. Even if these programs are not directly linked to official policy, the mandate itself allowed the Korean government to map a society in which the structure and intensity of conflicts are evident in order to prepare or adapt to sudden and unexpected changes (Calof, Smith, 2012; Vervoort, Gupta, 2018).

During the project implementation, strategies and methods "from present to future" (forecasting) and "from future to present" (backward forecasting) were simultaneously applied (Riedy, 2009). From the Korean case, it follows that the key condition for the successful integration of Foresight into the political agenda is the foresight of the government.

Cognitive issues

Foresight assessment is closely related to the topic of cognitive science. prejudices that largely determine the quality of projects. The influence of cognitive factors on the content of the quality of expert assessments has been studied since the 80s. (Hogarth, 1980; Hogarth, Makridakis, 1981; Schoemaker, 1993; Bradfield, 2008; Chermack, Nimon, 2008; Wright, Goodwin, 2009; Meissner, Wulf, 2013). There are many opportunities for error and bias that can affect the quality of future expectations at each stage (Bolger, Wright, 2017).

The classic problem is that experts have difficulty prioritizing and allocating time and resources to contribute (Videira et al., 2009; Carlsson et al., 2015). Research in cognitive psychology and social psychology reveals why cognitive biases are so common and persistent among participants in Foresight projects. This issue is widely discussed in both general review analyzes (Martino, 2003; UNIDO, 2004; Georghiou et al., 2008; Giaoutzi, Sapio, 2012), and when analyzing specific programs, for example, the German Delphi project II (Blind et al., 2001). Experts tend to project cause-and-effect relationships observed in their field of activity onto other fields. A fairly common bias is increased optimism about the future development of a field or technology (Tversky, Kahneman, 1974; Tichy, 2004). Scenarios often show an erroneous pattern: short-term forecasts are characterized by an optimistic mood, while long-term forecasts are pessimistic (Linstone, Turoff, 1976; Winkler, Moser, 2016; Markmann et al., 2021). Instead of holistically covering alternative possibilities, experts most often rely on familiar (limited) rules of thumb (heuristics). As a consequence, cognitive biases arise that influence the development of strategies (Kahneman et al., 1982).

There is a point of view that "about 80% of all technology forecasts turn out to be wrong" (Golden et al., 1994). Cognitive biases are manifested in the discrepancy between the actual results that people's behavior produced and the results that would be expected if people followed the rules of rational choice and probabilistic reasoning.

Experts are faced with complex cognitive processes that reveal diverse cause-and-effect relationships, the dynamics of dozens of variables, etc. The task is to build consistent ideas about possible future trajectories from a complex dynamic diversity. In technological forecasting, the result is distant in time and is often not formally assessed; the causal mechanisms are so complex that it is not obvious how to learn from the realized results.

The most common problem is overconfidence, which leads to an illusion of competence (Moore et al., 2015; Feld et al., 2017). It accompanies Experts do not quite correctly determine the confidence interval of their own estimates (Lichtenstein, Fischhoff, 1977), overestimate or underestimate what can be achieved over a certain period of time (Kahneman, Tversky, 1979; Sharot et al., 2012), create scenarios based on the development of the present in the future, and at the same time focus on optimistic scenarios (Newby - Clark et

[8] https://futures.kaist.ac.kr/en/?c=290, access date 02/12/2024.

Table 1. **Basic cognitive biases that appear at different stages of Foresight and ways to overcome them**

Foresight stage	Cognitive biases	Ways to minimize impact
Setting the project goal	Framing effect – an imbalance in semanti accents that affects the perception of context and decision-making. Experts focus on the benefits of technology and underestimate the risks and costs of its implementation.	Expanding the diversity of participants - carriers of different points of view, which, through the exchange of them, form a collective, more balanced "mental template" regarding technology. To change an individual's perspective, it is also suggested that alternatives be considered.
Technology Trend Analysis	Social desirability effect bias - the desire to formulate a point of view in such a way as to correspond to the prevailing collective ideas.	Analysis of trends in an abstract functional space, without reference to the prevailing social perception.
Analysis of technological options	Advocacy bias is the tendency of an expert who is well acquainted with a technology to focus on its advantages and remain silent about risks and costs.	Expanding the diversity of participants - carriers of different points of view allows us to expand the range of technological options put on the discussion agenda and challenge the dominant options. Different options are compared in an abstract function space.
Drawing up a technology roadmap	Planning fallacy - unfounded optimism and underestimation of the time required for the "maturation" of technology.	Regular review of the roadmap, deadlines and costs, identification of potential "failures", decomposition of the problem into more specific tasks.
User analysis	The "false consensus" effect - the tendency to project an individual way of thinking onto others, which leads to an underestimation of the share of potential users and an overestimation of the scale of technology adoption.	Regular systematic analysis of the reasons why users reject technology
Technology Maturity Analysis	The social desirability effect. The degree of technology maturity is underestimated and insufficient attention is paid to negative signals.	Regular system analysis of the technology's compliance with the declared functionality, assessment of potential failures at different stages of its life cycle
Market Analysis	Anchoring effect bias. Forecasts of the size of a new market are unreasonably tied to statistics on existing markets.	Creating an alternative "mental anchor" is allowing for a scenario in which the majority of users reject the technology.
Policy formation	Excessive confidence in one's own expert experience (overconfidence). It is expressed in a lack of understanding among politicians of how to apply Foresight results formulated by professionals.	Increasing the efficiency of communication between experts and decision makers, their involvement in the Foresight process at the initial stages

Source: adapted by the authors based on (Bonaccorsi et al., 2020).

al., 2000). They persist in this misconception even in the face of negative feedback (Buehler et al., 1994).

They make big mistakes in understanding exponential growth and formulate estimates that are largely inferior to the true values (Ebersbach et al., 2008; Levy, Tasoff, 2016; 2017). A related problem is the inability to identify rare events or low predictability events.

In this article, we cannot cover in detail the entire range of cognitive traps that participants in Foresight projects fall into. However, let's focus on solving the problem of cognitive biases. There is no single approach to overcoming them, so it is necessary to experiment with different combinations of methods. Strategies based on diversity, negation, and abstraction can mitigate biases that arise at any stage of the forecasting process.

Recently, tools have appeared that can directly or indirectly contribute to their leveling: full foresight, FAROUT, triangulation and self-assessment. When evaluating Foresight studies, it is necessary to take a retrospective approach, comparing current indicators with the results of technological Foresight obtained in the past, which complicates the process.

In table 1 systematized the main types of cognitive distortions that manifest themselves at different stages of technological Foresight, and approaches to overcoming them (Bonaccorsi et al., 2020) (Table 1).

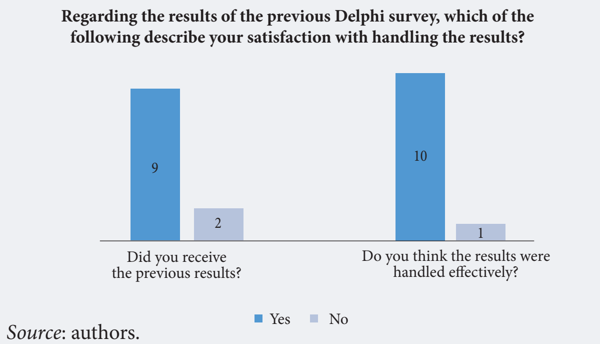
Based on this, our study attempts to evaluate the results of energy foresight - Egypt LEAPS, in terms of the results achieved and the forecasting process itself.

Foresight for the Egyptian Energy Sector

The first energy foresight for Egypt - Egypt LEAPS was initiated and implemented by the Academy of Scientific Research and Technology (Academy of Scientific Research and Technology, ASRT) in collaboration with Nile University (Nile University) and industry research centers (Rezk et al., 2019) in 2017. The national energy sector needed to develop development scenarios, taking into account technological, legal, social and political aspects. Two scenario horizons were defined - until 2022 and 2027. Implementation also took place in two stages. The first was a two-round Delphi survey, which examined about 180 topics, including technological and non-technological ones. They were distributed in 14 areas, including energy efficiency, creating an enabling environment, the use of fossil fuels and renewable energy sources. The timing of their technological "maturation", introduction to the market and the beginning of widespread practical use in Egypt was predicted (Rezk et al., 2019).

For the interim assessment of the project's results, three of these areas were selected: solar energy, ener-

Figure 3. **Respondent views on handling of results of previous foresight projects**



Source: authors.

Table 2. **Correspondence scheme adopted to determine the accuracy of the original foresight statements**

Egypt LEAPS Prediction	Expert Opinion in our Study	Verdict
2022	2022	Success
2022	2027	Failure
2022	Not yet realized	Failure
2027	2022	Failure
2027	2027	Success
2027	Will not be realized	Failure

Source: authors.

gy efficiency and fossil fuels. The overall effectiveness of communication in Egypt LEAPS and the accuracy of forecasts obtained using the Delphi survey were assessed five years after implementation, upon reaching the first horizon (2022). To assess the effectiveness of the Foresight process, an online survey was conducted of experts who expressed their level of satisfaction with the communication and the results obtained. Then the level of implementation of the assumptions made about certain directions of energy development was measured. Initial statements regarding expected implementation times made in 2017 were compared with the times reported by respondents to our 2022 assessment survey.

On this basis, conclusions were drawn about the correctness or error of Egypt LEAPS forecasts. Since the first of the horizons has already arrived, it became possible to conduct an intermediate assessment. If the events predicted for 2022 did not actually take place, these forecasts were classified as erroneous. As for the second horizon for 2027, if respondents agreed with its feasibility, then the reliability of the developed forecasts was considered to be maintained. If it turned out that the forecasts in question were realized ahead of time, or their horizon should be revised (for example, postponed beyond 2027), then they were also considered not relevant. In table Figure 2 shows the correspondence diagram used to evaluate the accuracy of the initial predictions.

Case analysis results and discussion

Survey results were collected separately for each of the energy areas considered: solar energy, energy efficiency and fossil fuels.

Our analysis of Egypt LEAPS results included 28 experts. It is noteworthy that all of them were involved in the evaluated Delphi process in 2017, but after five years only 11 of them remembered that they took part when they were sent invitations, which confirms the relevance of the problem of cognitive factors raised in the previous sections. Such cognitive lapses give reason to doubt the reliability of other results.

The majority of respondents (55%) to our survey confirmed that the research directions chosen for Egypt LEAPS were initially relevant.

Satisfaction with the level of organization of the project was 36% of respondents, the degree of agreement with the final scenarios was 9%.

This may indicate that the participants did not have sufficient knowledge and preparation for such projects. Some of those who were truly involved expressed satisfaction with the experience. Almost all of them highly appreciated the degree of accessibility of the project results, and in general characterized their processing as effective (Fig. 2).

The effectiveness criteria themselves were assessed based on several answer options (Fig. 3). It is noteworthy that the experts were not aware of the algorithm for processing completed Egypt LEAPS questionnaires; there is no description of it in the final report. The document also does not mention the subsequent use of the Delphi survey results. However, since stakeholders did respond to our question, we believe that they expressed their personal opinion about the importance of the project results.

To evaluate the results of the Delphi surveys, a correspondence table was constructed between the initial forecast estimates of Egypt LEAPS, actual data as of 2022 and new assumptions from our survey participants. There were more accurate forecasts than incorrect ones, although not by much (33 versus 26), which suggests the relative success of Egypt LEAPS. But more research is needed to identify the corresponding patterns (if any exist at all). An in-depth analysis showed that the majority of erroneous forecasts were related to energy efficiency (75% of those that were not confirmed). Estimates for fossil fuel and solar energy use were more accurate (18% and 36% wrong, respectively). This can be explained by the fact that improvements in energy efficiency are more difficult

Table 3. **Number of successful versus failed predictions on foresight project results**

Type	Success	Failure
Technical	17	13
Social	16	13
Source: authors.		

to predict. This area is characterized by a high degree of interdisciplinarity - its development depends on developments in areas, including outside the energy sector (for example, materials science, electrical engineering, etc.). There was no significant spread of successful and erroneous forecasts regarding the timing of technological and social implementation (Table 3).

In the Foresight project we studied, the level of involvement of politicians was insufficient, which caused the results to be disseminated inappropriately. As a result, they were unable to adequately influence decision-making. On the other hand, an unsatisfactory effect can be considered as a starting point for rethinking approaches to organizing subsequent Foresight projects and communication between participants in order to achieve their deeper involvement.

Conclusion

In the context of accelerating technology development, Foresight is an important tool for effective development strategies. The objective of this study was to evaluate the results of the energy foresight project Egypt LEAPS, based on the Delphi survey.

We interviewed the experts who participated. They were asked to analyze the accuracy of forecasts made for a five-year horizon, which had already arrived at the time of our survey. In addition, respondents expressed their opinion about the effectiveness of the Foresight process within Egypt LEAPS. The following practical and policy conclusions can be drawn from the assessment.

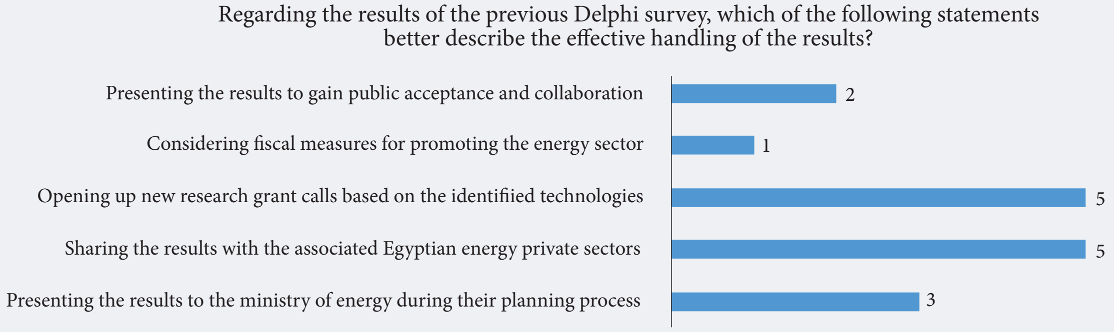
Technological Foresight is a large-scale, expensive and complex project that operates with a variety of methodologies and concepts that require careful assessment of each stage for the manifestation, including the cognitive biases of the participants.

This is especially true for developing countries, where, due to insufficient institutional efficiency, it leads to additional complication of the Foresight process.

To improve the effectiveness of future projects, it is necessary to understand what exactly happened after the implementation of the previous one. Our findings suggest that Foresight initiatives should include robust performance measurement mechanisms at the outset, rather than relying on ex-post approaches such as the one used in this study. We examined the potential of renewable energy in Egypt, primarily solar, and the practice of assessing foresight, paying special attention to working with the cognitive biases of participants in such projects. In order for technology foresight to become an integral part of the policy development process and expert recommendations to be taken into account when policymakers make decisions, it is necessary to ensure the necessary level of participation of the latter in the foresight. Measuring results and making incremental adjustments to the process are necessary to build trust and motivation to reduce false assumptions, building on new ways of dealing with complexity and uncertainty in dealing with the future.

Our findings highlight the need for sustained government support and active implementation of technology foresight in the energy sector and other critical industries to effectively stimulate long-term innovation and policy development. Technological Foresight should be a permanent priority of public policy, since some short-term initiatives quickly fade away, and their effect turns out to be very small or non-existent.

Figure 4. **Respondent estimations of statements for measurement the handling of foresight projects outcomes**



Source: authors.

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