A SCIENCE AND EDUCATION PLATFORM FOR INTELLECTUAL SUPPORT OF BREAKTHROUGH TEAMS IN THE ENERGY SECTOR

LAZAR D. GITELMAN & MIKHAIL V. KOZHEVNIKOV
Academic Department of Energy and Industrial Enterprises Management Systems,
Ural Federal University, Russia.

ABSTRACT
Making a breakthrough in the energy industry is a particularly laborious cross-disciplinary challenge due to the extreme complexity of production systems and the necessity to ensure the compatibility of a huge number of technologies and industrial and managerial systems of various nature. This makes it highly relevant to provide knowledge-intensive support for teams that implement projects aimed at breakthrough transformations. This article describes a specialized science and education platform that is being rolled out by the authors at a number of major energy companies in Russia and at Ural Federal University. The platform has features of a communications platform that brings together science, education, and energy companies, and of a digital ecosystem that serves as a framework for customized services for stakeholders. The platform uses an operation mechanism that is designed to ensure the reproduction of knowledge that is in line with corresponding trends and changes emerging in the global, national, and industrial contexts, and promptly converts it into learning content and a project agenda for breakthrough teams. An original methodology for the training of breakthrough teams and arguments for the appropriateness of using a platform-based approach in order to increase intellectual capital in the energy industry constitute the scientific novelty of the article. This article has a practical value to it as it demonstrates the scaling capability of the elements of the conceptual model, of its operation mechanism, and the best practices of using a science and education platform as the organizational basis for breakthrough projects in the energy sector.
Keywords: anticipatory learning, breakthrough team, energy sector, knowledge-intensive service, preemptive management, science and education platform, technological advances.

1 INTRODUCTION

Technology platforms have been a subject of intense scientific debate over the past two decades that saw an avalanche of innovations and growing competition in global markets for products, technologies, capital, and knowledge [1, 2]. Once a niche IT term used for a set of hardware for installing and launching applications [3], today the platform is one of the trendiest concepts among economists, marketing professionals, managers, and engineers.

In the simplest terms, a technology platform is a combination of technologies in a certain area of knowledge that could be created at the level of a company or an organization or an industry as an essential condition for their innovative development, and as a tool ensuring a nation's technological sovereignty – at the macro-level. At the level of global markets, platforms are an instrument driving forth the development of the platform economy that completely reshapes the principles of competition, innovative development, and global trade as a whole [4–6]. At the very dawn of the concept, a technology platform was predominately defined as a means (an instrument, an infrastructural framework, and a communications platform) for bringing together the efforts of the state, business, education, and sciences for the sake of technological breakthroughs and innovative development of the country's economy. Today, the semantic focus has shifted towards the organization of a flexible, self-sustaining business. According to this approach, a large company acts as the provider of future technology, with numerous smaller contractors, research centers, various technological and logistics

ISSN: 2056-3272 (paper format), ISSN: 2056-3280 (online), http://www.witpress.com/journals
DOI: 10.2495/EQ-V7-N4-388-400

services and, most importantly, consumers gravitating towards it. The key «product» of the platform are services (or, more rarely, tangible products) that are built upon a unique technological architecture [7].

A platform-centric approach enabled many hi-tech companies to become global leaders by market capitalization (Fig. 1). As a result, the trend towards platform-based business models has emerged in companies engaged in key industries, including the energy sector, as they seek to produce customized comprehensive solutions (Table 1).

The subject of this study is a specific kind of platforms – science and education ones. On the one hand, such platforms have features of cross-industry consortia that are created for solving complex non-linear problems [9]. On the other hand, they are organizing systems for technical, information, and intellectual assets in a digital environment. Access to the system enables participants to jointly create streams of bundled knowledge-intensive products and services [10]. Opportunities for employing science and education platforms in the energy

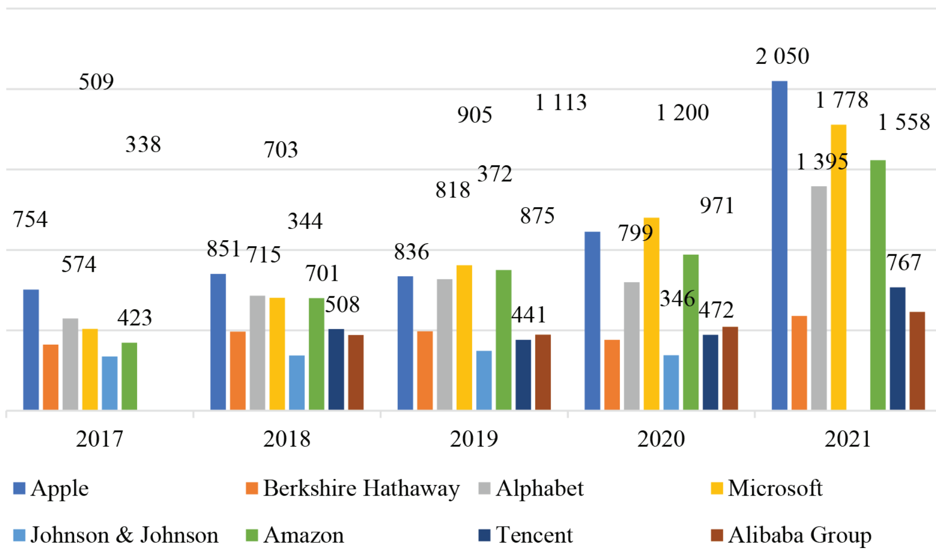

Figure 1: Development dynamics of digital platform-based businesses (billion dollars).

Table 1: Industries with the highest potential for embracing platforms, % [13].

Industry	Global	USA	China	India	Japan	UK
Automotive/transportation	13	13	18	14	13	16
Consumer markets/retail	11	13	14	9	7	8
Education	8	13	8	5	13	5
Energy	8	5	6	14	0	10
Healthcare	12	11	11	6	17	11
Industrial manufacturing	10	10	4	8	13	15
Media	14	18	11	6	13	18
Telecom	10	7	16	12	23	5

sector are explored in this work through the case of an extremely urgent industry-specific task – that of preparing breakthrough teams for implementation of radical transformation projects as a new format of energy production and the industry's involvement in the energy transition [11, 12].

2 THEORETICAL BACKGROUND AND METHODS

2.1 Prospects for use of platform-based instruments in the energy industry

«Platform thinking» in the global energy industry is still at the early stages of taking shape. The first industry-related works on the subject matter were published in the early 2010s. Among the factors highlighted by the literature as necessitating the creation of platforms in the energy sector are trends towards decentralization, the expansion of renewable energy sources (RES), customer centricity, the industry›s integration with other urban infrastructure sectors, the emergence of prosumers – those who both consume and produce electricity [14]. Platforms, therefore, represented the electric power industry's response to growing pressure from new factors and players that were previously ignored [15].

Demand for platforms increases gradually in three interconnected segments that differ in terms of the core technologies at the heart of their architecture (Table 2).

In the first segment, key transformations take place within grid companies and electricity resellers that have a radically higher degree of interaction with end users, the system operator, dispatch structures, and energy service companies (ESCOs) thanks to the adoption of smart meter technologies. In the EaaS segment, energy companies – and energy resellers in the first place – are making a transition to a model of selling packages of knowledge-intensive services (e.g. creation of customized microclimate or integrated management of utility infrastructure) based on energy consumption management by means of adaptive information

Table 2: Examples of emerging platforms in the electric power industry [16].

Segment	Basic technology	Key participants	User groups
Smart grids	Smart grids and smart metering systems	• Grid operator • Power dispatcher • ESCOs	Large power companies Power consumers
«Energy as a service» (EaaS)	Adaptive information and telecom systems	• ESCOs • Specialist telecom companies • Data processing centers • Suppliers of auxiliary knowledge-intensive service (finances, commerce, consulting)	Retail electricity providers or independent power producers Electricity consumers
Electric vehicles	Charging network coupled with energy storage and accumulation systems	• Specialist companies providing maintenance for charging infrastructure • Demand side response aggregator • Telecommunication company • Data processing center	Retail electricity providers Power dispatcher Power consumers

and communications technologies. Finally, platforms are taking over the EV industry, necessitating the emergence of new market agents – independent organizations or subsidiaries of energy companies that manage energy flows between energy-consuming devices and the grid. The emergence of platforms is, therefore, a major transformative force for the business models of energy and service businesses.

Platforms have enjoyed a particularly robust growth in the «energy-as-a-service» segment. The logic of this business model implies that rather than selling electricity or heat, the company sells a package of services (creating a customized microclimate in a room, integrated administration of households' utilities and home infrastructure, energy storage management) that are of real value to consumers and that utilize energy carriers as their basis [17, 18]. EaaS contracts that use platform instruments as their technological framework have increasingly spread around the world: the EaaS market is projected to reach 220 billion dollars by 2026 (Fig. 2).

In fact, without platform tools, no breakthrough innovations can be implemented today in the energy sector. Platform tools serve as a technology ensuring higher flexibility and maneuverability of energy systems [20] and form the technological foundation of the Internet of Energy [21]. Platform tools are also an essential element for the operation of smart grids [22], virtual power plants [23], smart contracts [24], and the demand-side management (DSM) market [25]. Nevertheless, some researchers [21, 26] observe that the potential of platforms is not fully exploited yet in the power industry. This is due to a shortage of a relevant methodological toolkit and of a comprehensive summary of practical experience, primarily from the perspective of the economic expediency of their implementation.

2.2 Definition, classification, and the authors' experience of training breakthrough teams

The authors define a technological breakthrough as a *system-structured process of radical transformations that occur in the technological foundation of production on the basis of the latest advancements in science and technology, and a process of associated transformations in organizational, economic, and social systems.* Such a breakthrough implies the deployment of fundamentally new solutions for products, technology, and organizational structure, an accelerated build-up of the intellectual potential of manpower for bringing industries and

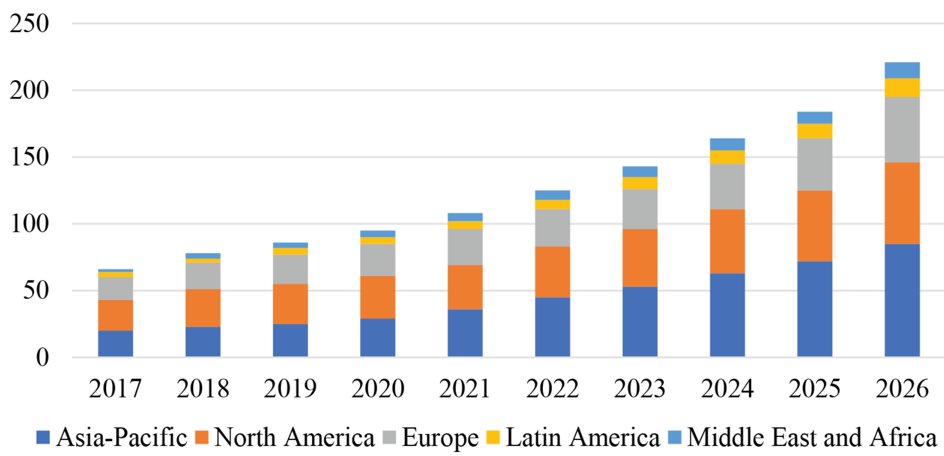

Figure 2: Global EaaS market in commercial and industrial sectors (billion dollars) [19].

economic sectors to leadership positions in the market. As a result, new markets are created, while the existing production sites either become fully transformed or disappear completely [27, 28].

A breakthrough team is a cross-disciplinary team consisting of highly qualified professionals (managers, engineers, economists, lawyers, IT specialists, and external experts) that possesses a strong perception of the context, a comprehensive vision of prospects and competencies for implementing new business models.

Breakthrough teams boast the following competencies:

- they are capable of seeing beyond the boundaries of the system and of understanding the future impact of transformations taking place in the external environment on the system;
- they are able to assess the opportunities and risks brought about by transformations in terms of the available resources, intellectual potential, and time;
- they see development trajectories for workers and can identify points of growth along the development path;
- they possess skills for design thinking and conceptual engineering.

A training model for breakthrough teams depends on the nature of the organization, its strategic goals, peculiar features of the market and industrial technologies, available resources and a large number of other factors. There is, however, a number of common starting points that make the creation of such teams easier.

1. Is the breakthrough domain known to the company, or is it completely new? The domain could be of high-tech nature requiring a substantial amount of new knowledge and investment, or a conventional one.
2. What is planned to be created? Is it going to be something totally unique and previously unknown to consumers, or is it going to be an improved version of an existing product/technology?
3. Is it necessary to engage outside experts and knowledge-intensive support services, or is the breakthrough going to be made in-house by utilizing available competencies?
4. Are there time constraints for project implementation, or is it going to be a long-cycle project?

Depending on the answers, experts with consulting firm Arthur D. Little [29, 30] identify several model options for breakthrough teams (Fig. 3).

The two most «advanced» models of Fig. 3, namely, the 'interdisciplinary team' and the 'breakthrough factory team' (Table 3), shall be looked at in more detail; these models are used by the authors as prototypes in their work.

When training breakthrough teams in energy companies, the authors used the organizational models above, paying special attention to junctions (interdisciplinarity) when an assembly of teams is formed, in which each team is responsible for its own block in the innovation process (Fig. 4). As a rule, teams are built to work in three key areas: renewal and upgrade of assets and construction of new energy infrastructure on a cutting-edge research and technology foundation; deployment of the latest digital technology in the production and management contours of the energy business; creation of flexible management systems in energy companies that would make it possible to preemptively respond to opportunities and threats in the external environment; customization of knowledge-intensive service support

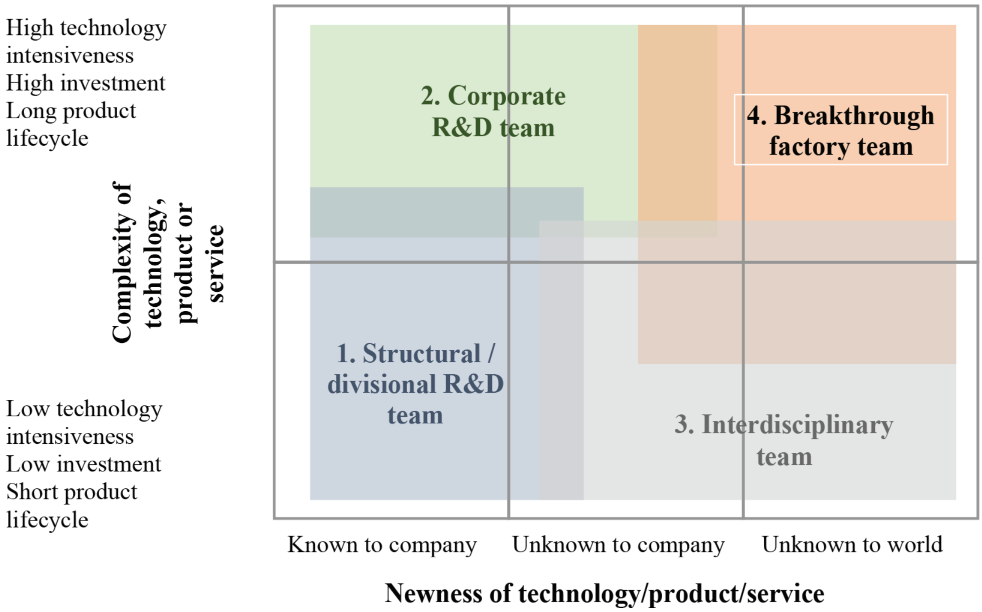

Figure 3: Matrix for selecting the target model for the training of a breakthrough team.

(targeted R&D programs, equipment support and maintenance services, and complex engineering of energy facilities).

Teams are offered a wide range of situational projects that could include, for example:

- making provisions for the company's strategy in a digital environment;
- preparation for systemic transformations on the basis of the engineering of the future;
- energy asset management amid uncertainty;
- the environment and competency for a breakthrough into promising energy markets;
- diversification of the energy company's business as a strategic leadership tool.

The authors have successfully trained breakthrough teams for a number of Russia's major energy companies. In the case of T Plus, for example, the teams were engaged in the formation of a strategic vision of the business and the development and testing of relevant technological and economic solutions. This enabled them to design three innovative projects in a matter of 18 months that were presented to the top management. The projects with a horizon of 5 years and the direct economic effect amounting to 500 million roubles envisaged the penetration of new markets, renewal, and launch of new fixed assets, changes in the corporate culture and the policy on the professional development of employees [31].

No less important is the indirect economic effect that took the form of a bank of innovation projects, optimization proposals, higher workforce productivity thanks to stronger team interactions between employees and units, lower cost of production due to the implementation of advanced technological and scientific solutions and, most importantly, a higher level of the energy company's preparedness to handle to unexpected negative events and, therefore, lower costs of emergency response.

Table 3: Characteristics of target models.

	Target model	
Parameters	Interdisciplinary team	Breakthrough factory team
Definition and application specifics	Team formed from professionals from various domains and parts of the business (business units, corporate research centers, financial, and project units). Reports directly to senior management.	The team administers packages of applied research programs, aiming to solve an unsolvable problem for the market or to introduce a technology (product) innovation that would lead to a market breakthrough. Autonomous unit within a corporation that reports directly to the board of directors.
Conditions for efficiency	The innovation domain is unfamiliar to the company. Has access to outside expertise and resources (intellectual in the first place).	The domain is technology intensive and scientific and is completely new to the company. Radical transformations (technology development/unique product launch) are planned. Agile approach is used.
Benefits	Launches exchange of knowledge and experience across the entire business.	High pace of innovation processes that drives up the speed and creativity within other teams, too. Starts a selection (attraction) mechanism for top talents and experts. Sets up a nursery for radical ideas
Challenges	Requires a leader and a binding methodology, the absence of which makes a mixed team dysfunctional. Disproportions might occur within the team (in terms of proficiency level, areas of expertise, positions)	Can be seen by majority of employees as an overly academic structure that is disconnected from business practice. Requires unconventional business metrics for team performance appraisal

In another energy company, Bashkirenergo, a team of top managers was established to implement the nation's first pilot project of grid digitalization on the basis of the Smart Grid concept [32].

Since 2012, the authors have also been involved in training breakthrough teams at Ural Federal University. Since its launch, over 70 people have graduated from the project. The technology makes it possible for the teams to focus, within a short period of time, on acquiring forward-looking knowledge and carrying out relevant projects of strategic nature. The positive effect of the training on career growth is remarkable: over 50% of participants took leadership positions in various institutions and units; five persons defended their PhD theses that were derived from their projects implemented within the program. The following list of the research projects undertaken by the program participants emphasizes their extreme relevance:

- the development of innovation centers and laboratories at UrFU («Cyclotron Center for Nuclear Medicine», «Urals Center for Managing the Development of Smart Grid Intellec-

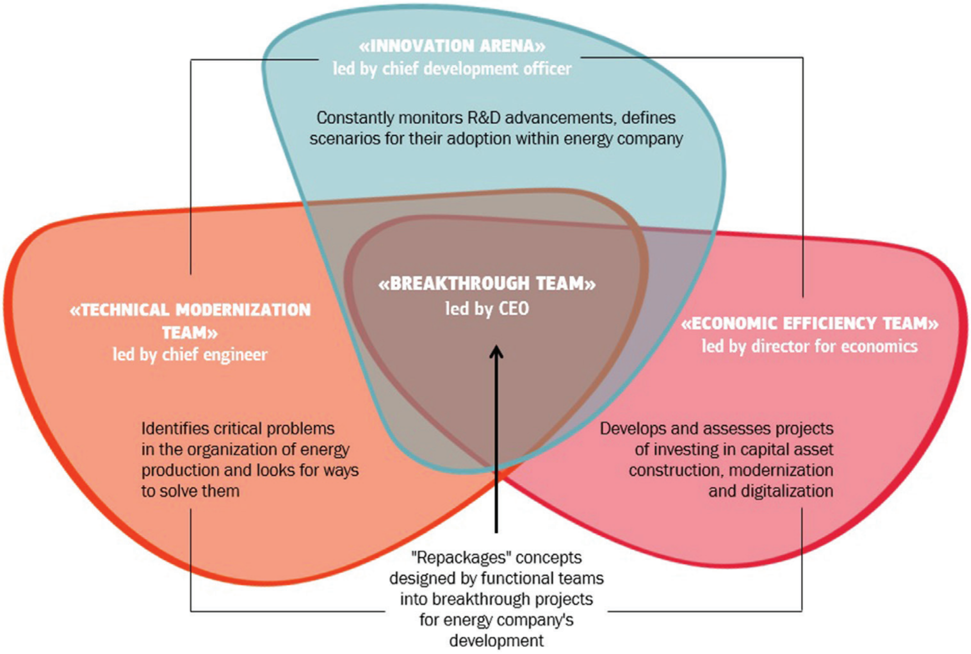

Figure 4: Assembly of breakthrough teams.

tual Electric Power», and «Electromagnetic Compatibility Laboratory»);

- development strategies for institutes, including Urals Energy Institute, the largest industry competency center in the Russian Federation;
- cross-disciplinary master's degree programs and additional professional education courses, including those intended for foreign students;
- innovative educational environments and teaching methods.

3 SCIENCE AND EDUCATION PLATFORMS PROVIDING SUPPORT FOR BREAKTHROUGH TEAMS

As mentioned above, breakthrough teams work on projects that are extremely complex, have a fuzzy structure and are plagued by substantial risks. All too often, there is not enough knowledge, let alone real-life experience for solving such project tasks. It is obvious that intensive knowledge support for breakthrough teams is the key factor of their successful performance.

As a tool of providing such support, the authors have designed a specialized science and education platform (Fig. 5). The mechanism of the platform envisages that it will cyclically run over a number of iterations.

1. On the premises of the science and education center ENGEC at Ural Federal University, the analytical contour is created for the continuous monitoring of changes in the external environment of the energy business, its allied industries and markets, trends that have a direct and indirect impact on the industry's possible future state or, in other words, of strong and weak signals.

2. Trends that have been identified are sieved through a scientific filter – a research program that was designed as part of the breakthrough scientific domain «Preemptive management in rapidly developing industries and sectors».
3. Current research projects make it possible to generate new knowledge that is yet to find practical application, to build an agenda for promising industrial tasks and competencies that are in demand with managers and energy company specialists.
4. The list of tasks and competencies is used as the basis for anticipatory learning content that is delivered with the assistance of outside faculty experts and real sector professionals. It also provides the core for a program of service support for breakthrough teams.
5. The content is verified for being up to date with emerging trends in the industry. If it is not, the cycle is repeated.

The operation mechanism of the platform ensures the circulation and reproduction of new knowledge that is in line with corresponding promising trends and changes happening in the global, national, and industrial contexts.

Structurally, the platform is built upon four original key technologies:

Conveyor for continuous competency enhancement is a technology that enables the HR departments of energy companies to plan the development of breakthrough team members by means of:

- anticipatory leaning programs that provide for continuity of education across various phases;
- taking into account career plans, personal, and corporate interests;
- flexible modifications of the content and format of learning in line with tasks being solved (Fig. 6).

Digital knowledge base that contains over 50 proprietary course books and 400 journal articles. The knowledge base makes it possible to radically transform the instruction process

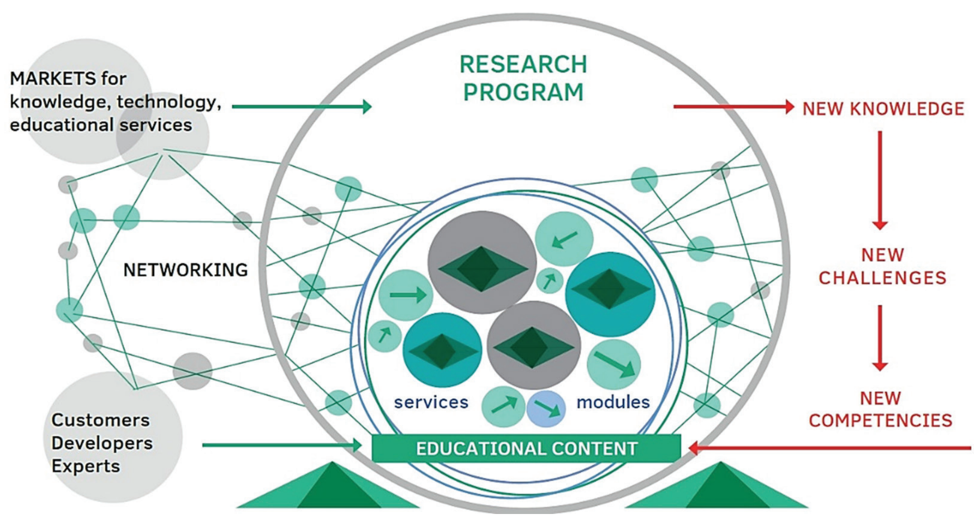

Figure 5: Conceptual image of science and education platform mechanism.

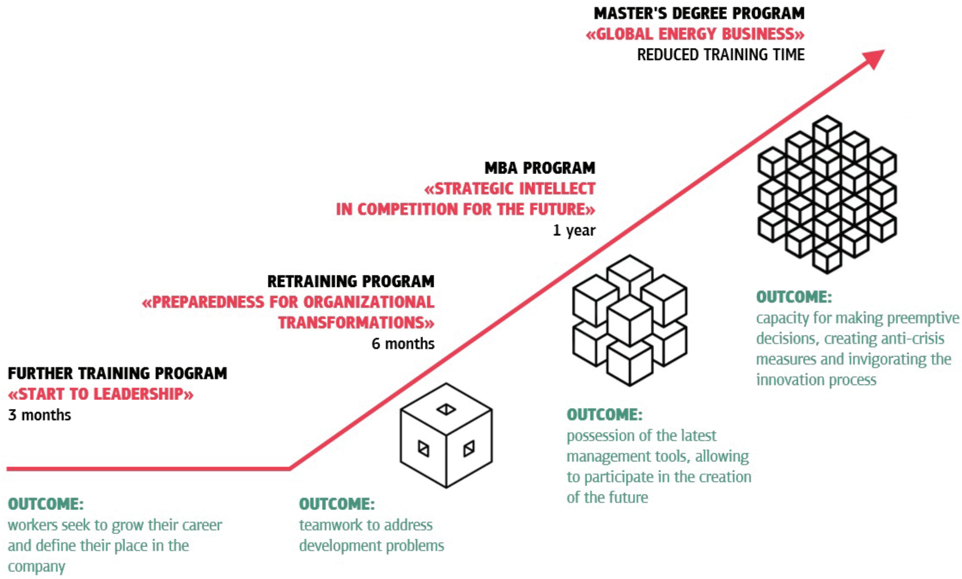

Figure 6: An example of a conveyor for continuous competency enhancement.

by leaving theoretical aspects for self-study and freeing up time for focusing on problem areas and acquiring cross-disciplinary knowledge and competencies.

Electronic anticipatory learning system combines educational content, methods, information, and service support for anticipatory learning that focuses on the exploration of development problems and timely decision making for managing non-standard future situations.

«*Module in Module*» – is a technology that improves the flexibility of the learning process by allowing for a variability in the proportion of educational, research, innovation, and projects events in educational modules depending on the team's objectives and the participants' own preferences.

As a result, the science and education platform performs several essential functions of support for breakthrough teams.

1. It ensures the constant influx of knowledge, methods, instruments for complex problem solving and a transfer of innovative ideas and cutting-edge practices between the energy company and the university.
2. It helps to swiftly detect gaps between the current competence level in employees and future industrial challenges, to plan critical personal development trajectories for workers and to make arrangements for their technology training.
3. It makes it possible to finalize the development of breakthrough projects in terms of their strategic and economic expediency and to initiate their rollout.

4 CONCLUSIONS

Technology platforms are used in the energy sector for the purpose of solving unique super-complex problems that are new and non-linear, while lacking a sufficient bank of interdisciplinary knowledge and the essential analytical base. They can function as self-regulatory consortia or scalable business ecosystems that adapt flexibly to market demand thanks to their unique technological architecture. Platforms enable direct economic communication between businesses in a market without the involvement of intermediaries and additional capital and operational costs imposed by the market infrastructure.

Platforms are particularly in demand in allied segments, such as:

- smart grids, due to the radically growing intensity of interactions among grid companies and energy sellers and end users, the grid operator, dispatch organizations, ESCOs. This has become possible thanks to the adoption of smart metering technologies;
- in the «energy-as-a service» segment, whereby energy companies are making a transition to a model of selling packages of knowledge-intensive services that are based on energy consumption management by means of adaptive information and communication technologies;
- the EV industry, following the emergence of new market agents – independent organizations or subsidiaries of energy companies that manage energy flows between energy-consuming devices and the grid.

The concept of the science and education platform that is presented in this article is a comprehensive methodological and organizational toolkit that provides a boost to breakthrough teams working on super-complex interdisciplinary problems. Breakthrough teams address tasks that require a change to the existing paradigm of business organization, so their key role is to transform the conventional perspective on systemic development and to design radical innovative solutions. At the same time, team members continue to work with their units, promoting ideas among their co-workers. So-called growth points appear that do not affect the integrity of the entire system but serve as a trigger that ensures the flexibility of the development of individual system components.

The key advantage of the science and education platform is that it promptly carries out the transfer into the educational process of the newest R&D advancements that define the emerging structure of industries, markets, and models of interaction between producers and consumers. The platform, therefore, takes the shape of a decentralized communication network, whose participants use unified technologies methods and tools.

The availability of such a science and education platform enables energy companies to move to a new level of strategic development, thanks to, among other things, the possibility of embracing preemptive management and thereby ensuring the company's preparedness to withstand unexpected challenges in the external environment. This provides it with a capability to consider multiple scenarios of the impact of context changes on the energy business, which constitutes an important condition of its sustainable operation and development.

ACKNOWLEDGEMENTS

The research funding from the Ministry of Science and Higher Education of the Russian Federation (Ural Federal University Program of Development within the Priority-2030 Program) is gratefully acknowledged.

REFERENCES

[1] Langley, P. & Leyshon, A., Platform capitalism: The intermediation and capitalisation of digital economic circulation. *Finance and Society*, **3(1)**, pp. 11–31, 2017.

[2] Asadullah, A., Faik, I. & Kankanhalli, A., Digital platforms: A review and future directions. *PACIS 2018 Proceedings*, **248**, 2018, https://aisel.aisnet.org/pacis2018/248/. Accessed on: 23 August 2022.

[3] Fichman, R. G., Real options and IT platform adoption: Implications for theory and practice. *Information Systems Research*, **15(2)**, pp. 132–154, 2004.
[4] Evans, P. C. & Gawer, A., The rise of platform enterprise: A global survey. https://www.thecge.net/app/uploads/2016/01/PDF-WEB-Platform-Survey_01_12.pdf. Accessed on: 23 August 2022.
[5] Nambisan, S., Wright, M. & Feldman, M., The digital transformation of innovation and entrepreneurship: Progress, challenges and key themes. *Research Policy*, **48(8)**, Paper 103773, 2019. https://doi.org/10.1016/j.respol.2019.03.018
[6] Athey, S. & Luca, M., Economists (and economics) in tech companies. *Journal of Economic Perspectives*, **33(1)**, pp. 209–230, 2019. https://doi.org/10.1257/jep.33.1.209
[7] Gawer, A., Bridging differing perspectives on technological platforms: Toward an integrative framework. *Research Policy*, **7(43)**, pp. 1239–1249, 2014.
[8] The Changing Landscape of Disruptive Technologies. Tech Disruptors Outpace the Competition. https://assets.kpmg/content/dam/kpmg/pl/pdf/2018/06/pl-The-Changing-Landscape-of-Disruptive-Technologies-2018.pdf. Accessed on: 23 August 2022.
[9] Gitelman, L. D., Kozhevnikov, M. V. & Sandler, D. G., Technology platforms as a tool for solving complex innovation problems. *International Journal of Design and Nature and Ecodynamics*, **11(4)**, pp. 584–592, 2016. https://doi.org/10.2495/DNE-V11-N4-584-592
[10] Robertson, D. & Ulrich, K., Planning for product platforms. *Sloan Management Review*, **39**(4), pp. 19–31, 1998.
[11] Henderson, J., *The energy transition: Key challenges for incumbent and new players in the global energy system*. The Oxford Institute for Energy Studies, 2021. https://www.oxfordenergy.org/wpcms/wp-content/uploads/2021/09/Energy-Transition-Key-challenges-for-incumbent-players-in-the-global-energy-system-ET01.pdf. Accessed on: 23 August 2022.
[12] Tian, J., Yu, L., Xue, R., Zhuang, S. & Shan, Y., Global low-carbon energy transition in the post-COVID-19 era. *Applied Energy*, **307**, Paper 118205, 2022. https://doi.org/10.1016/j.apenergy.2021.118205
[13] KPMG, *The Changing Landscape of Disruptive Technologies*. Tech Disruptors Outpace the Competition. https://assets.kpmg/content/dam/kpmg/pl/pdf/2018/06/pl-The-Changing-Landscape-of-Disruptive-Technologies-2018.pdf. Accessed on: 23 August 2022.
[14] Lawrence, M., *The Next Phase of the Energy Transformation: Platform Thinking*. https://www.renewableenergyworld.com/storage/the-next-phase-of-the-energy-transformation-platform-thinking/. Accessed on: 23 August 2022.
[15] Weiller, C. M. & Pollitt, M. G., *Platform markets and energy services*. Working Paper, 2013. https://www.eprg.group.cam.ac.uk/wp-content/uploads/2013/12/1334-PDF.pdf. Accessed on: 23 August 2022.
[16] Gitelman, L. D. & Kozhevnikov, M. V., Adoption of technology platforms in the electric power industry: new opportunities. *WIT Transactions on Ecology and the Environment*, **255**, pp. 23–34, 2022. https://doi.org/10.2495/EPM220031
[17] Wedekind, S., *Energy as a Service: A Strategic Challenge and Key Opportunity for ESCOs*. https://energycentral.com/o/Guidehouse/energy-service-strategic-challenge-and-key-opportunity-escos. Accessed on: 23 August 2022.
[18] Wedekind, S., *Energy Service Companies Face Increasing Pressure from Energy as a Service*. https://guidehouseinsights.com/news-and-views/energy-service-companies-face-increasing-pressure-from-energy-as-a-service. Accessed on: 23 August 2022.

[19] Energy-as-a-Service. *The lights are on. Is anyone home?* Deloitte, 2019. https://www2.deloitte.com/content/dam/Deloitte/uk/Documents/energy-resources/deloitte-uk-energy-as-a-service-report-2019.pdf. Accessed on: 23 August 2022.

[20] Sector Coupling in Europe: Powering Decarbonization. *Potential and Policy Implications of Electrifying the Economy*. Bloomberg, 2020. https://data.bloomberglp.com/professional/sites/24/BNEF-Sector-Coupling-Report-Feb-2020.pdf. Accessed on: 23 August 2022.

[21] Martín-Lopo, M. M., Boal, J. & Sánchez-Miralles, Á., A literature review of IoT energy platforms aimed at end users. *Computer Networks*, **171**, Paper 107101, 2020. https://doi.org/10.1016/j.comnet.2020.107101

[22] Gitelman, L. D., Kozhevnikov, M. V. & Adam, L. A., Sustainable energy for smart city. *International Journal of Energy Production and Management*, **4(4)**, pp. 343–353, 2019. https://doi.org/10.2495/EQ-V4-N4-343-353

[23] Muradoğlu, S. N. & Deniz, D., Smart energy applications and integration of urban furniture into smart systems in cities. *International Journal of Energy Production and Management*, **7(2)**, pp. 127–139, 2022. https://doi.org/10.2495/EQ-V7-N2-127-139

[24] Damisa, U., Nwulu, N. I. & Siano, P., Towards blockchain-based energy trading: a smart contract implementation of energy double auction and spinning reserve trading. *Energies*, **15**, Paper 4084, 2022. https://doi.org/10.3390/en15114084

[25] Baev, I., Dzyuba, A., Solovyeva, I. & Kuzmina, N., Improving the efficiency of using small-distributed generation systems through mechanisms of demand management for electricity and gas. *International Journal of Energy Production and Management*, **3(4)**, pp. 277–291, 2018. https://doi.org/10.2495/EQ-V3-N4-277-291

[26] Duch-Brown, N. & Rossetti, F., Digital platforms across the European regional energy markets. *Energy Policy*, **144**, p. 111612, 2020. https://doi.org/10.1016/j.enpol.2020.111612

[27] Seba, T., *Clean Disruption of Energy and Transportation: How Silicon Valley Will Make Oil, Nuclear, Natural Gas, Coal, Electric Utilities and Conventional Cars Obsolete by 2030*. California: Tony Seba; Beta edition, 2014, 290 p.

[28] Seba, T., *Solar Trillions – 7 Market and Investment Opportunities in the Emerging Clean-Energy Economy*. San Francisco: Tony Seba, 2010, 292 p.

[29] Francis, R., Härenstam, F. & Eagar, R., Organizing for breakthrough innovation. Structures for systematically developing and exploiting radical ideas. *Prism*, **1**, pp. 12–28, 2015.

[30] Kazemahvazi, S., Roos, D. & Eagar R., The Breakthrough Factory. A concept for serial breakthrough innovation. *Prism*, **1**, pp. 30–38, 2015.

[31] Gitelman, L.D., Gavrilova, T.B., Kozhevnikov, M.V. & Starikov, E.M., Ensuring resilience and agility of complex organizational-technical systems. *International Journal of Design and Nature and Ecodynamics*, **13**(2), pp. 208–220, 2018.

[32] Makarov, A.Yu., *Power Grid Digitalization. Practical Experience*. Ekonomika: Moscow, 2019, 128 p.