ADOPTION OF TECHNOLOGY PLATFORMS IN THE ELECTRIC POWER INDUSTRY: NEW OPPORTUNITIES

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ABSTRACT

The paper defines the key areas of application and economic effects of platform tools in the electric power industry. This is a new approach that boosts the development of knowledge-intensive services on the basis of integration of utilities, consumers, developers and digital solutions providers into a single eco-system, which enables the accumulation and update of knowledge on the systems and processes being serviced. Using theoretical analysis and their specific hands-on experience, the authors prove that the application of platform tools delivers an economic effect through a greater volume and speed of energy transactions, the adoption of innovations by energy companies in their commercial and production operations, faster transfer of new knowledge between platform stakeholders, and creation of knowledge-intensive services for pro-active consumers on the basis of new knowledge. The scientific novelty of the study is that it gives a systemic overview of theoretical and methodological conceptions of platforms tailored for the electric power industry, which is a complex infrastructure industry, from the perspective of the economic expediency of their implementation. The findings could be of interest to various parties involved in energy and economic relations when implementing projects focusing on modernization, energy transition, energy conservation, improvement of consumer interactions with the employment of the latest communication interfaces.

Keywords: electric power industry, technology platform, knowledge-intensive service, business model, demand side management, transaction.

1 INTRODUCTION

The widespread adoption of the technology platform concept is closely associated with the accelerated development of innovations in many countries and stronger competition in research intensive markets. The new reality implies that the creation and adoption of breakthrough innovations in high-tech industries is impossible without the close cooperation of various “agents” – companies, universities, research and science centers – and without the development of effective mechanisms for the transfer of knowledge and technology or the creation of strategic alliances, including at the industrial and state levels.

In Gitelman et al. [1], the authors prove that roughly all interpretations of the concept “technology platform” match one of two approaches. Under the first one, a technology platform is a self-regulating consortium that is created for solving super complex problems, typically of scientific and technical nature. Problems that are undertaken by such platforms are always unique and one-of-a-kind, new and non-linear, while lacking a sufficient bank of knowledge, especially in cross-disciplinary fields, and the essential analytical base.

More popular, though, is the so-called “product” or “market” approach that suggests looking at the technology platform as a starting ground for businesses seeking to build their own eco-system (a new market segment). According to this approach, a large company acts as a future technology provider, with numerous smaller contractors, research centers, various technological and logistics services and, most importantly, consumers gravitating toward it. The key “product” of the platform are services (or, more rarely, tangible products) that are built upon unique technological architecture [2].

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Within the framework of the second approach, a technology platform can be defined as a peculiar system for organizing technical, information and intellectual assets in a digital environment. By using the platform, participants are able to jointly create streams of bundled products and services that provide unique consumer value that can be modified in line with customer preferences by quickly adding new components to the products or removing unneeded ones [3].

By using the second approach, many high-tech companies were able to become global leaders by market capitalization. As a result, it is platform companies who boast the highest business value, outpacing significantly traditionally built companies (Fig. 1).

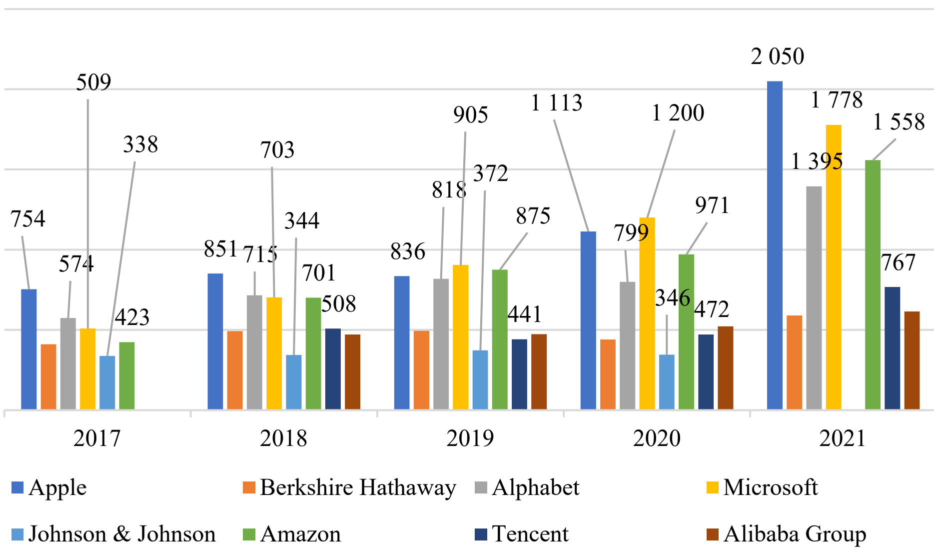

Figure 1: Development dynamics of digital platform-based businesses (billion dollars).

The pioneers of platform business models are companies, such as Apple or Amazon, that essentially do not own any tangible assets. In the past few years, though, the trend towards platform-based business models has emerged in a number of heavy industry sectors (Table 1).

Table 1: Industries with the highest potential for embracing platforms (%) [4].

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

Among the factors that warrant the creation of platforms in the electric power industry there are trends towards decentralization, the expansion of RES, customer centricity, integration between energy and other urban infrastructure sectors, the emergence of prosumers – those who both consumer and produce electricity [5], [6]. Platforms are gradually finding demand in three neighboring industries, yet they differ in terms of the core technologies that form the foundation 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 structure, and energy service companies (ESCOs) thanks to smart meter technologies. In the energy-as-a-service segment, energy companies – and primarily energy resellers – a transition is under way to a model of selling packages of knowledge-intensive services (e.g., creation of customized microclimate or integrated management of utilities infrastructure) based on energy consumption management by means of adaptive information and communications technologies. Finally, platforms are taking over the electric vehicle (EV) industry, calling for the emergence of new market agents – independent organizations or subsidiaries of energy companies that would 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.

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

Segment	Basic technology	Key participants	User groups
Smart grids	Smart metering systems	• Grid operator • Power dispatcher • ESCOs	Large power companies Power consumers
Energy-as-a-service	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 company providing maintenance for charging infrastructure • Demand side response aggregator • Telecommunication company • Data processing center	Retail electricity providers Power dispatcher Power consumers

Some studies [7], [8] say, however, that the electric power industry does not take full advantage of platforms' potential, which is due to a shortage of the necessary methodological tools and a comprehensive review of actual experience, especially from the point of view of the economic expediency of their implementation. This study aims to produce a systemic overview of promising trends and to substantiate potential economic effects of the implementation of platform solutions that use the latest technologies, including from the field of digitalization, in the electric power industry.

2 METHODOLOGICAL FOUNDATIONS FOR ECONOMIC INTERACTION BETWEEN PLATFORM STAKEHOLDERS

The literature on platforms contains two contradicting views as to the arrangement of economic relations among platform stakeholders [9], [10].

2.1 View 1

Platforms must be viewed as participating in several one-sided markets, that is, each side must be considered as interacting with the platform in a separate market. Analysis of effects on competition assumes that any action that makes the situation worse for users in any of the markets, such as a price hike enforced by the platform for one of the sides, constitutes a sufficient ground for considering the platform's actions as undermining competition.

As the platform provides its service to each of the sides separately, it is logical to look at two separate markets in which the platform provides information to participants about transaction options. This, however, reveals a "zero price problem", meaning that one of the groups of participants could connect to the platform free of charge and avoid paying for its services. The connection of one of sides to the platform is de facto subsidized by another side. In that case, many competitive analysis tools do not work because it becomes impossible to analyze price increases. Meanwhile, zero or negative pricing could be the platform's deliberate strategy because, for example, allowing users on one side to connect to the platform free of charge produces positive indirect external effects (by increasing the value of immediate contact through platform) for the subsidizing side. All else being equal, the pricing structure offered by the platform is neutral, while the price set for one of the groups of users connecting to the platform depends on the price being paid by users from another group.

2.2 View 2

Platforms are naturally designed to build connections between sides, so in order to analyze the boundaries of the commodity market, it is necessary to consider all sides connecting to the platform, and indirect network effects. The key parameter for analysis is the presence of the "transfer pricing effect" accompanying transactions: one of the sides connecting to the platform can change the prices and, by doing so, fully pass the changes to the price set by the platform on to the counterparties it interacts with through the platform. If the effect is observed, for the sake of competitive analysis it would be advisable to study separate markets where the platform sets prices for each of the groups of users being studied. This is due to the fact that platforms that face the price transfer effect are unable to internalize emerging indirect effects by changing their pricing structure, which means their multi-sided business model does not play any role in price setting.

One can decide whether to examine one multi-sided market or several interconnected markets where no price transfer effect is observed by looking at whether or not the platforms allow transactions between the sides. In this regard, one should distinguish between non-transaction matching platforms, non-transaction audience-providing platforms, and transaction platforms that are capable of carrying out transactions between sides and receive a fee for both connection and usage.

If platform users on both sides connect to it in order to find a user on the other side, it is reasonable to say that the platform provides a matching service. In that case, competitive analysis should be performed for one multi-sided market.

If a least one of the user groups connects to the platform in order to access certain content rather than to get information about transaction options, we deal with the case of audience markets that should be considered as several interconnected markets.

A summary of the views explained above is given in Table 3.

A conclusion can be made that the adoption of platforms increases the versatility of the forms of economic interaction between customers and vendors on the basis of emerging direct and indirect network economic effects [12], [13].

Table 3: A summary of views on analysis of market boundaries across platforms [9]–[11].

Indicator	Transaction platform		Non-transaction platform	
Price carryover effect	No	Yes	No	Yes
Matching services	Yes	Yes	Yes	No
Indirect external effects	+	+	+	+/–
Preferred analysis perspective	One multi-sided market	Several one-sided markets	One multi-sided market	Several connected markets

Direct effects are mainly associated with the communication capabilities of platforms that enable them to generate a constant growth of users and transactions thanks to the unique value provided by the platform. As a rule, the value takes the form of access to exclusive offers, analytics or technological architecture that is designed for the production of new services. Access to the platform can be fee-based or free for one or all engaged sides. The economic logic of the platform-based business model is described by the following logical sequence: *user growth → growth in demand for services on offer → growth in prices of services on offer → revenue and profit growth*. The key costs for platform owners are (1) the cost of user acquisition and support; (2) capital and operating costs of developing, creating and maintaining the operability and of the future expansion of the information infrastructure of the platform; (3) associated recruitment costs, the cost of legal support and other platform management processes. The second group – so-called infrastructure costs – includes multiple components and is determined by the technological nature of the platform. It can, for example, depend on the costs of data mining, their transformation and subsequent upload into data centers, data protection costs, analytical query response times [14], the amount of processed information, the types of connection in the network, the structural and functional architecture of the platform [13].

An access fee usually covers operating costs, but it slows down user growth. At the same time, the presence of a "registration fee" reduces the number of unscrupulous users (including spam generators and cyber criminals), so ultimately it helps reduce per-user service costs.

If a platform focuses strictly on matching customers and vendors of various services, i.e., if it acts as a digital middleman, the direct economic effects for the platform owner could be a commission over transactions and revenue from content placed by sponsors or advertising clients.

Considering the above, a general direct economic effect E_{plt} of platform deployment can be calculated by the equation:

$$E_{plt} = \sum_{i=1}^{n} Q_i + \sum_{i=1}^{n} Q_i \cdot K_t + Fee \cdot N - C_i - C_c - C_a, \qquad (1)$$

where Q_i is the financial outcome of the i-th transaction a service, K_t is the percentage of commission on transactions across the platform, *Fee* is the platform access fee, *N* is the number of platform users, C_i are infrastructure costs, C_C are customer acquisition and support costs, C_a are auxiliary costs.

This equation is usable by a platform owner regardless of whether he or she is also the service supplier (transaction beneficiary) or only works to select vendors and service suppliers. The key difference is that in the second case the first summand is equal to zero.

In order to assess the direct economic effect for service producers and service customers who use a platform as a digital communication tool, one should use modified variants (2) and (3) of the above equation:

$$E_{plt}^{producer} = \sum_{i=1}^{n} Q_i + \Delta C_i + \Delta C_a - \sum_{i=1}^{n} Q_i \cdot K_t - Fee, \tag{2}$$

where ΔC_i and ΔC_a are the change in infrastructure and auxiliary costs incurred by the producer when he or she sells services independent as opposed to platform involvement;

$$E_{plt}^{customer} = \Delta P + \Delta C_i + \Delta C_a - Fee, \tag{3}$$

where ΔP is the change (reduction) in the price of the service offered by the platform.

It is worth saying that *indirect economic effects* that emerge in the course of platform interaction are essential for a service customer. They appear when the platform helps the customer increase the efficiency of individual processes (e.g., reduce the cost of service production, boost productivity and operability, reduce the risk of breakdown, receive consulting support). For example, platform tools can enable the users to exchange knowledge and information or provide access to other IoT units for real-time control.

It should be emphasized that a direct effect is only generated by transaction platforms, while non-transaction platforms only produce indirect economic effects.

3 PRACTICAL AREAS OF PLATFORM USAGE IN THE ELECTRIC POWER INDUSTRY

We shall consider areas of platform application in the electric power industry as a promising knowledge-intensive service and take a detailed look at how forms of economic interaction between energy and service companies change as a result of the adoption of platform tools.

3.1 Faster and more transparent energy transactions

Within this trend, transaction platforms help various agents engaged in energy and economic relations to communicate almost in real time while considerably improving the quality of data on energy consumption and related costs. For example, Fig. 2 shows how a digital platform that is integrated into a regional system for power sales management, first of all, delivers on the popular concept of customer centricity. Second, it connects not only all traditional energy market players, but also service providers from various segments in one network; third, it creates an analytical base for addressing comprehensively a number of energy companies' present-day problems that are associated with the technological issues of power supply. Such platforms can be accomplished by means of a three-layer scheme. The first layer of the platform is installed on the consumer's side; the second is installed on the energy supplier's side; and the third one is on the market side. All three layers are connected via a cloud service-oriented interface [15].

Such platforms are capable of delivering current and retrospective consumption data and bill settlements by constructing load charts online. They can pay electricity bills and give suggestions as to possible energy savings throughout the day, coordinate the charging of electric vehicles in a city, advise EV owners on the potential of using EVs as power generators in energy-hungry regions; inform consumers about power outages by sending an app notification; deliver updates on the energy system status (failures, overloads, disruptions, change of rates, installation works, validation of electricity meters); and provide guidance on energy efficient behaviors.

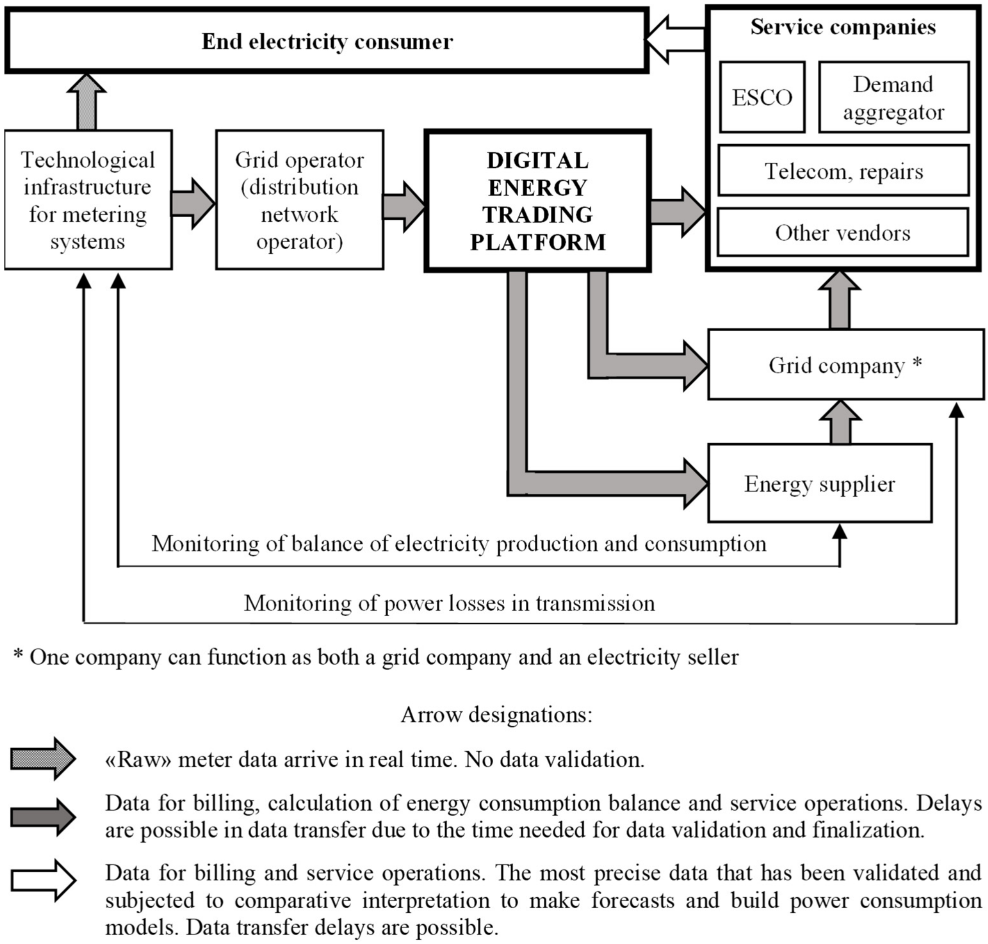

Figure 2: A model of interaction among energy companies, consumers and service organizations when platform tools are used for energy transmission.

We shall describe an economic effect that could be achieved by deploying a similar platform that is being designed now by an independent energy seller that operates in a number of Russia's regions. In addition to actual energy supply services, the company installs automated commercial energy metering systems (ACEMS) and conducts energy audits for households as well as industrial customers.

It is supposed that the platform will enable:

1) an increase in private individuals among the company's subscribers thanks to an application with a customized interface that contains analytical information on current and retrospective power consumption (free of charge). There are plans for enhancing the platform with solutions for "smart home" management and maintenance of smart metering systems and with appropriate energy infrastructure (to be available for a service fee), which would mean a transition to the "energy-as-a-service" business model.

2) an improvement in the quality of energy consumption management and optimization in industrial customers by means of integration between ACEM systems with the platform with an outlook for services that would create a digital twin of the customer's energy supply system.

The company owns the platform and intends to carry out information and technological maintenance of the platform independently. The platform is being developed by a specialist IT company. Immediate (infrastructure) costs C_i are estimated at 12 million roubles (around 160,000 dollars at the current exchange rate); the expenditures are to be made in the first year; annual operation costs (to acquire and support customers and carry out maintenance, $C_c + C_a$) are estimated at 2.4 million roubles in the first year of the project; and 2.6 million roubles in the second year.

Between 2022 and 2023 the company plans to use the platform as a marketing instrument and attract 1,500 new subscribers in the first year and another 3,500 in the second year. This should make it possible to increase electricity sales by about 31.2m kWh and increase revenue by 3.1 million roubles given the estimated retail markup of 0.1 roubles per kWh. Additionally, the company expects to undertake the maintenance of some 100 households with installed "smart home" systems (revenue will be accrued from the platform subscription fee totaling 0.5 million roubles and payments for service works amounting to 5.5 million roubles). Industrial customers are expected to generate 1.2 million roubles in platform access fee and some 10 million roubles for ACEMS installation and maintenance.

The platform rollout costs will, therefore, total 17 million roubles within a period of two years; revenue is projected at 20.3 million roubles and the combined economic effect – at 3.3 million roubles.

In the case of larger energy retailers that act as guaranteeing suppliers and service cities with populations exceeding one million, the economic effect of platform deployment would be much (dozens of times) greater. This is due to the number of subscribers as well as their retail markups that is lower at independent energy retailers.

In the case described above, the transition to a platform-based business model amplifies a number of other direct and indirect economic effects that are achieved thanks to the installation of ACEMSs: lower costs of energy consumption data collection and processing for billing purposes; lower costs of inspection of parameters and quality assurance of energy consumption metering; reduction of business losses and receivables; expanded functionality and greater flexibility of interactions with customers thanks to better understanding of their load schedules and payment structure, which enables the development of more rational end economically reasonable electricity tariffs.

3.2 Demand side management

For the full implementation of this essential mechanism of energy efficiency, regions need to have special technology infrastructure. Digital *transaction* platforms based on the internet of energy, artificial intelligence and big data analytics can prove to be an effective infrastructural solution. The grid operation could act as the platform owner at the initial phase and will see its role reduced to a minimum at later stages as the demand aggregator and the customer will get more freedom to perform transactions. They use the platform to independently file applications for load reduction; bidding is scheduled automatically; a demand aggregator is selected that meets the criteria; and technical conditions for contract implementation are determined. The key issues to be addressed as part of this model are associated with enabling access to the platform for generators, demand aggregators and consumers, the creation of adequate user interfaces, and defining the platform administrator mandate. The costs of creating and maintaining the operation of the platform could be covered either by a demand side management (DSM) surcharge imposed by the grid operator, or by a percentage charge deducted from the profits of demand aggregators. The size of the charge is to be established by law.

3.3 Asset management

Non-transaction platforms enable a transition to progressive risk-oriented strategies that imply continuous equipment condition monitoring and forecasting of possible outages in various nodes of technical systems. When using technology platforms as a knowledge-intensive solution enabling energy companies to radically rethink their production principles and those of relations with service vendors and customers, the key risk is posed by uncertainty as regards the right choice of assets that would make it possible to design a sufficient number of customized services in the long run without raising a large amount of additional investment [17]. The selection of assets that would enable an energy company to function in line with the platform model happens at the very initial stage of a production system overhaul. That is why it becomes ever more important to ensure close connections between the asset management strategy, the corporate strategy and the product strategy [18].

An example of platform utilization for asset management is the Cablewalker platform for robotic power line inspection that is being developed by the authors [19]. The platform enables the creation of an exact digital 3D model of a grid facility – a digital twin [20], containing information about the condition of every key element. A digital twin, in its turn, makes it possible to effectively manage the condition of grid assets that are hard-to-access for technical reasons. Test runs of the inspection method showed that up to 98% of defects on overhead transmission lines can be detected.

Another example is the organization of IoT-based tools for intellectual repairs and maintenance services on the basis of platforms [21]. Under the traditional approach, an energy company collects and stores information about the performance of mechanical and electrical equipment in a special database where the data is aggregated. The system is usually capable of calculating indirect parameters on the basis of technological process data, the current and retrospective conditions of mechanical and electrical equipment, and inspection results. The new approach envisages the platform-based globalization of various data influencing the equipment lifecycle. The system organizes the collection and processing of statistical data in real time, increasing the accuracy of the assessment of equipment condition and remaining lifetime and engaging remote users in the assessment process. With the application of the platform approach, the intellectual repairs and maintenance system acquires a number of essential system properties: scalability (capacity for integration with other systems; capacity for self-learning (the ability to change configuration settings during operation); self-organization (the ability to remain operational when new functions are added).

3.4 Arrangements of knowledge transfer between energy companies and universities

Platforms are self-organizing network structures whose objective is to generate new knowledge for tackling future industrial problems. In this context, *specialized science and education non-transaction platforms* are of particular demand.

The operation mechanism of such platforms (Fig. 3) ensures the circulation and multiplication of new knowledge that matches promising trends and developments in the global, national and industrial contexts. Their continuous monitoring and analysis make it possible to generate knowledge and convert it into concrete projects and research tasks. To address them, a portfolio of specific competences that are in demand by the market is needed [22].

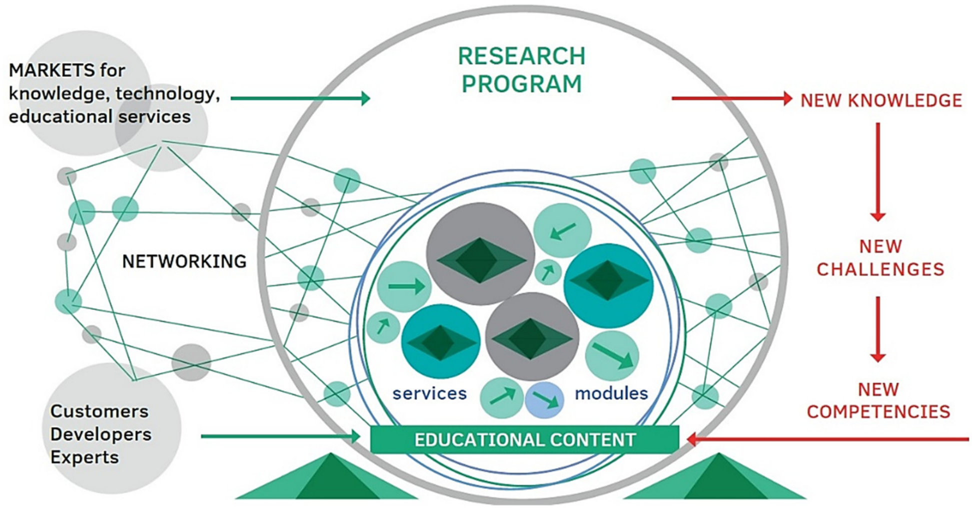

Figure 3: Conceptual image of science and education platform mechanism.

A knowledge base serves as the foundation for creating knowledge-intensive services across a science and education platform. The data base of the platform created by the authors on the premises of Ural Federal University contains over 50 proprietary course books, 400 articles and publications, making it possible to radically transform the instruction process by leaving theoretical aspects for self-study and freeing up time for focusing on problem areas and acquiring cross-disciplinary knowledge and competencies. The key services of the science and education platform are access to the knowledge base, publication collaborations [23], formation of breakthrough teams for unique projects, innovation tours, including online, of pioneering companies, design and adjustment of a specialist's personal development trajectory.

4 CONCLUSIONS

Technology platforms find growing adoption in manufacturing for the purpose of solving unique super-complex problems that are new and non-linear, while lacking a sufficient bank of knowledge and the essential analytical base. They can function as self-regulating consortiums or as scalable business eco-systems that produce services that flexibly adapt to market demand thanks to their unique technological architecture. Businesses using platforms for marketing are able to interact economically and directly with peers without any middlemen and additional capital and operation costs of financing market infrastructure.

In the electric power industry, platforms find demand in the following interconnected segments:

- 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, 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 authors show that platform-based instruments can be used in the electric power industry for addressing the following tasks: ensuring faster and more transparent energy transactions; price-dependent demand side response; asset management, knowledge transfer between energy companies and universities. All customers and suppliers of knowledge-intensive services are engaged in the implementation of these trends, which results in the arrival of new business models both within service companies that focus on customized high-tech industries, and energy companies, who see their economic behavior logic change towards a bigger share of services in the structure of their product offer instead of maximization of the sales of their standard core product (electricity).

It is worth noting that the implementation of the suggestions set out in this article requires further elaboration on certain debatable aspects that have to do with the creation of a regulatory framework for platform-based energy markets, cyber risk management throughout platform operation, integration of platforms with different technological architectures. These issues pose an interest for further research.

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