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Emerging platform business models among the European electric utilities

Nowe modele biznesu platform wśród europejskich grup energetycznych

Abstract: The European energy sector is under a rapid change in business models due to the energy and digital transformations. The implications of these transformations are emerging platform business models among electric utilities and emerging electricity value chain in the energy sector. The study of platform business models among electric utilities is important, because they integrate the sector's value chain and determine the transformations of the energy sector. In this paper, the current platform business models managed by electric utilities are analysed empirically and theoretically. The analysis covers 26 European electric utilities. The analysis aims to identify the classes of the platform business models for electric utilities. As a result, 28 digital platforms are identified and grouped into 9 business model classes. This paper examines how the electric utilities have employed novel business models. It provides evidence that, in the face of energy and digital transformations, the electric utilities are the key players in digital platform implementation in Europe.

Keywords: energy transformation, digital transformation, electric utilities, business models, platform business models

Streszczenie: Europejski sektor energetyczny przechodzi intensywną zmianę modeli biznesu w związku z transformacją energetyczną i cyfrową. Konsekwencjami tych przemian są pojawiające się modele biznesowe platform wśród dużych przedsiębiorstw energetycznych oraz nowy łańcuch wartości w sektorze energetycznym. Badanie modeli biznesowych platform wśród tych przedsiębiorstw jest ważne, ponieważ integrują one łańcuch wartości sektora i determinują transformację sektora energetycznego. W niniejszym artykule przeanalizowano empirycznie i teoretycznie obecne mode-

le biznesu platform zarządzanych przed przedsiębiorstwa wertykalnie zintegrowane w sektorze energetycznym. Analiza obejmuje 26 europejskich przedsiębiorstw. Celem analizy jest identyfikacja klas modeli biznesu platform dla przedsiębiorstw energetycznych. W rezultacie zidentyfikowano 28 platform cyfrowych i pogrupowano je w dziewięć klas modeli biznesowych. W niniejszym artykule przeanalizowano, w jaki sposób przedsiębiorstwa energetyczne zastosowały nowatorskie modele biznesu. Jest to dowód na to, że w obliczu transformacji energetycznej i cyfrowej przedsiębiorstwa energetyczne są kluczowymi graczami we wdrażaniu platform cyfrowych w Europie.

Słowa kluczowe: transformacji energetyczna, transformacji cyfrowa, przedsiębiorstwa energetyczne, modele biznesu, modele biznesu platform
JEL: L22, L23, O13, P28, Q42

The literature analysis on digital platforms and their business models shows that although more and more space is devoted to them, the scope of those relating to the energy sector is overlooked or only superficially examined. Business models in the energy sector are constantly changing (Woodhouse, Bradbury, 2017). So far, based on their competitive advantages, electric utilities have used the traditional business models. Due to their lumpiness, traditional business models have recently been adapted to the dynamic changes in the context of digital and energy transformation. This paper provides evidence about the participation of electric utilities in the digital and energy transformations through the platform business models.

Progressive climate change and environmental degradation threaten the world and the people. The European Union (EU) is taking action to achieve climate neutrality by 2050. Climate neutrality means the maximum reduction of GHG emissions in all sectors of the economy and the compensation of those emissions that have not been reduced by increasing absorption of CO_2, e.g. by increasing the area of forests.

The COVID-19 pandemic has highlighted the importance of digitisation in the economy and society. During this crisis, digital technologies proved to be crucial in education, work and services. For many companies, digitisation has proved essential to business continuity. The European Commission (EC) has announced the digital transformation of the EU economy.

The energy and digital transformations became the main forces of change in most sectors of the economy and a source of innovation. Such transformations are an opportunity to include new entities and social groups in the process of generating energy.

On the electricity supply side, there is a shift towards low- or zero-emission generation sources, i.e. renewable energy sources (RES). Renewable energy is characterised by high production variability, which creates a problem related to balancing energy

networks. The issue of the network balancing results from the limited possibilities of using the surplus of electricity produced from RES and ensuring the electricity supply in the event of a lack of its production from RES. In addition, electricity generated from RES is challenging to store due to the lack of required storage capacity since this technology is still immature. On the demand side, prosumers play an increasingly important role as they take more control over energy management. On both sides, small-scale electricity supply or demand resources are connected to the distribution grid, so-called distributed energy resources (DER). Examples of DER are roof-top photovoltaic (PV) panels, wind generation units, battery storage, batteries in electric vehicles, heat pumps etc. Energy security is equally essential for both sides of the market. The critical element in ensuring energy security are electric utilities. A digital solution that is currently gaining importance in many energy systems in the world is the digital platform. By definition, digital platforms combine dispersed resources (Kloppenbur, Boekelo, 2019), the ownership of which is decentralised (e.g. in apartment rental services – Airbnb) or centralised (e.g. in car rental services – Car2go). The business models of platforms have thus become the subject of many studies in the service sector, i.e. hotel industry or transport. The research on phenomena remains outside the mainstream in the energy sector. The digital platform implemented by the electric utility is one of the responses to the challenges mentioned above in the energy sector.

The digital transformation in the energy sector is still a market niche because, as shown in this article, despite the significant involvement of electric utilities, they have not developed many digital platforms. Electric utilities are crucial for this sector's energy and digital transformation processes. There are state-owned electric utilities operating in Europe, and their owners are deeply interested in transforming their entities. Without electric utilities, the transformation of the energy sector is impossible since they are vertically integrated and operate in almost every activity segment, except for electricity transmission.

The energy transformation changes the operating conditions of electric utilities. The centre of gravity in the value chain is shifting towards DER. Digitisation only accelerates this process. The digital and energy transformations disrupted the way of energy and information flow within the electricity value chain. The traditional value chain supported one-way information and electricity flow from centralised generation to end customers (Doleski, 2016). Currently, digitalised energy ecosystems support two-way flow. Platform business models are one of the solutions that will make it easier for electric utilities to adapt to such aew operating conditions. Electric utilities must be supported by solutions that, on the one hand, will include DER into the value chain, and, on the other hand, will not destabilise the distribution network. Technologies such as digital energy platforms can accelerate both transformations by

catalysing the interactions between the electric utility, customers and DER owners (Evans, Hagiu, & Schmalensee, 2004; Kagermann et al., 2015).

In the face of the changes mentioned above, the following research questions arise:

1. What makes electric utility owners interested in platform business models?
2. What kind of platform business models are implemented by electric utilities?
3. What is the impact of implementing business platform models for their participants?

This paper presents the existing platform business models among the largest electric utilities in Europe with the purpose of identifying their classes. The classes are drawn up based on the conclusions from the analysis of literature and the key drivers and the consequences of energy platform implementation by electric utilities.

In the rest of the paper, section 2 describes the methodology used and the data employed for the analysis. Section 3 introduces the determinants of transformation and an emerging business models. Section 4 describes the role of electric utilities in developing platform business models. Section 5 discusses the platform business models in the energy sector. In section 6 the conclusions are drawn.

Methodology

A combination of theory-based and practice-based approaches minimises individual assessment bias. Such a procedure is especially needed when analysing new business models due to its high dynamics of changes. The purpose of the applied method is to determine the classes of platform business models in the energy sector based on their characteristics defined in the literature, as well as the existing platforms among electric utilities.

In the first step, a practice-based approach was taken and primary data was collected. Primary data comes from the largest publicly traded electric utility companies headquartered in the EU. The primary data on platform business models was collected via publicly available information, i.e. from the electric utilities' websites (including their annual reports), energy sector platforms related websites, papers and databases.

In a theory-based approach the literature was analysed and secondary data was collected to identify the critical business model characteristics. Identified characteristics were evaluated for uniqueness and fit for the energy platform business model to compile the prototypes. The business model prototypes were grouped into the following three categories:

1. Activities to be performed within the platform.
2. Actors that perform these activities.
3. Assets employed by the actors to perform these activities.

This three-dimensional categorisation is essential for the description of digital platform business models. For example, Osterwalder and Pigneur (Osterwalder, Pigneur, 2013) proposed to include key activities, key resources and key partners to describe business models in the field of infrastructure. Such grouping of the energy platform business model prototypes is also important in the context of electric utilities. Activities indicate the platform implementation's key drivers and the consequences for electric utilities. Actors perform them within assets. Leaders (i.e. electric utilities) are the owners of the platform and their assets. Activities provide value for both the leader and participants of the platform. The grouped prototypes are presented in Table 1.

Table 1 Energy platform business model prototypes grouped into three categories.

No.	Activities	Actors	Assets
1	Active Network Management (ANM)	big-box retailer	Advanced Metering Infrastructure (AMI)
2	aggregating Distributed Energy Resources (DER)	commercial customer	Artificial Intelligence (AI)
3	analysis of production yield	Distributed Energy Resources (DER) owner	blockchain
4	ancillary activities	electricity broker	Combined Heat and Power (CHP)
5	consulting services	electric utility	control system
6	consumption analysis	Electric Vehicles (EV) user	Distributed Energy Resources (DER)
7	crowdfunding	electricity grid operator	Electric Vehicles (EVs)
8	data interoperability	electricity producer	EV charging infrastructure
9	data monetisation	electricity supplier	Energy Management System (EMS)
10	data protection	Energy Community (EC)	energy storage
11	Demand Side Management (DSM)	Energy Service Company (ESCO)	Financial Technology (Fintech)
12	electric vehicle-to-grid (V2G)	energy storage provider	flexible energy equipment
13	energy efficiency services	home improvement company	hydropower
14	energy management	homeowners	Internet of Things (IoT)
15	energy performance contracting (EPC)	housing companies	machine learning
16	energy supply contracting (ESC)	industrial customer	Renewables (RES)
17	facilitating access to capital	Local Authority (LA)	smart grid
18	flexibility services	municipal customer	smart home devices
19	forecasting	organisation	solar PV panels

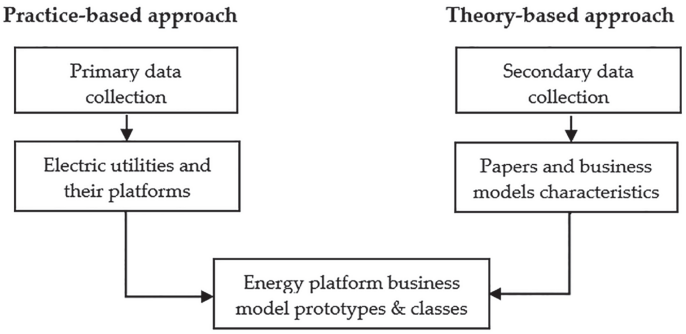
No.	Activities	Actors	Assets
20	integrated energy contracting (IEC)	prosumer	telecom network
21	leasing a renewable energy equipment	Renewable Energy Cooperative (REC)	thermal plant
22	load aggregation	Renewable Energy Sources owner	transmission & distribution network
23	operating charging points	software provider	utility-scale renewable
24	peer-to-peer energy	start-up	wind power
25	providing balancing services	telecom network operator	
26	real-time metering		
27	renewable generation		
28	satellite imaging		
29	sector coupling		
30	selling renewable energy		
31	smart meter services		
32	storage of energy		
33	supply stabilisation		
34	support for conventional production		
35	technical services		
36	utility bill tracking		

Source: own elaboration based on literature.

The purpose of identifying the business model prototypes in the energy sector is to generally describe the business models implemented by the electric utilities analysed in the practice-based analysis. The prototypes were assigned to each of the existing platforms. The platforms with similar prototypes were grouped into classes with specific names and functions.

The platforms with similar prototypes were grouped into classes with specific functions. The main principle for separating a class of platforms was that the classes are mutually exclusive and collectively exhaustive in terms of assigned prototypes. Multiple allocations of one prototype to two or more classes are permitted. Nevertheless, the developed classes are unique in terms of their activities. The business model prototypes and classes represent a snapshot of the current energy sector. Current classes might no longer exist in the long run, while new classes might emerge. The method applied in this paper is presented in Figure 1.

Figure 1 **The method applied for analysis of the emerging platform business models among the European electric utilities.**



Source: own elaboration.

Energy and digital transformations

The digital and energy transformations disrupted the way of energy and information flow within the electricity value chain. Traditionally the electricity value chain took place behind the meter. The traditional utility value chain (Figure 2) is based on generating and selling electricity from large-scale thermal power plants through the transmission and distribution grids to meet customers' and regulators' needs. This value chain represents a one-way energy flow from the electric utility to the end-use customers.

Figure 2 **Traditional electricity value chain**

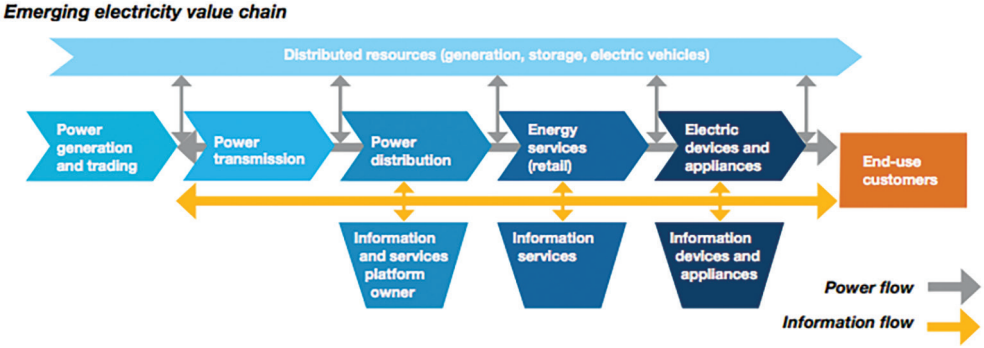
Source: IBM Institute for Business Value, 2010.

According to Doleski (Doleski, 2016), the energy sector is currently at the beginning of its fourth phase of transformation, so-called Utility 4.0. Utility 1.0 was before the liberalisation of the energy market in the 1990 s. Power distribution and retail were integrated within one electric utility. Liberalisation separated those two segments (so-called unbundling) and the classic energy supply companies (Utilities 2.0) were created. In the 2010 s, electric utilities started to transform into energy services companies (Utilities 3.0). Utilities 4.0 offer more networked products to address flexible generation and demand response. As a result of digitisation in the energy market, companies

providing digital services are emerging. They operate either in the conventional energy, renewable energy market or both simultaneously. This increases the number and scope of private entities' activities in these markets. In Utility 4.0, we are witnessing the collapse of established business models, which could slow down the shift toward sustainable and climate-neutral systems (Markand, 2018). Technologies such as digital energy platforms can accelerate the transition by catalysing the interactions between traditional power generation, distributed energy resources, power distribution, energy services, electric devices and appliances, customers and electric utilities.

The emerging electricity value chain (Figure 3) brings energy out behind the meter. As the shift to decentralised resources follows, the interactions of customers and the power grid are becoming more frequent. A new line of information flow to the electricity value chain has been added. In this respect, digital platforms can play a significant role in facilitating two-way energy and information flows.

Figure 3 Emerging electricity value chain



Source: IBM Institute for Business Value, 2010.

Understanding the business models emerging in the energy sector is significant for ensuring the continued economic viability of critical electricity infrastructure that provides safe-and-reliable electricity. The business model concept is frequently used in academic research and management practitioners as a classification and visualisation tool for companies and their activities (Loock, 2013; Richter, 2013). In the literature, the term "business model" denotes a simplified abstraction of corporate activities that aim to generate profit (Giehl et al., 2020). According to Osterwalder and Pigneur, a business model is "the rationale of how an organisation creates, delivers and captures value" (Osterwalder, Pigneur, 2013).

A handful of studies examine business models in the energy sector. Still, these studies give low regard to how electric utilities employ digital solutions in RES business mod-

els (Bell et al., 2014; Wainstein, 2016). In recent years, there has been a growing interest in emerging business models of platforms within the energy sector (Duch-Brown, Rossetti, 2020). In publications on the European energy platform business models, a relatively large amount of space is devoted to the energy transformation in Germany (Yildiz A. et al., 2017; Engelken et al., 2016). German publications indicate the trend of the emergence of new business models that compete with the traditional models of electric utilities (Fuchs G. et al., 2016; Löbbe, Hackbarth, 2017). The platform is usually perceived as a set of subsystems and interfaces (Gawer, Cusumano, 2014) that make up the company's business ecosystem (clients, partners, programmers, institutions, etc.) or is only used by the company (Pakulska, Poniatowska-Jaksch, 2021). The digital platforms are understood as a system of constant core components and variable peripheral components (Baldwin, 2018; Tiwana, 2014). In particular, they are intermediaries and enable interactions and exchange of values between at least two different, interdependent participant groups (Evans, 2016; Gassmann et al., 2020; Lozic et al., 2017). Platform participants take different roles (i.e. leader, integrator, complement) (Nambisan, 2019) and show various types of interdependencies resulting from their cooperation to create value within this platform (Pakulska, Poniatowska-Jaksch, 2021). The leader's role is to provide basic infrastructure and create an ecosystem of various platform users. Leaders can also use multiple strategies of access to the platform, including licensing (Pakulska, Poniatowska-Jaksch, 2021). On the other hand, the users of digital platforms exchange services, products, or information to create value for at least one of the participant groups (Choudary et al., 2015; Eisenmann et al., 2006).

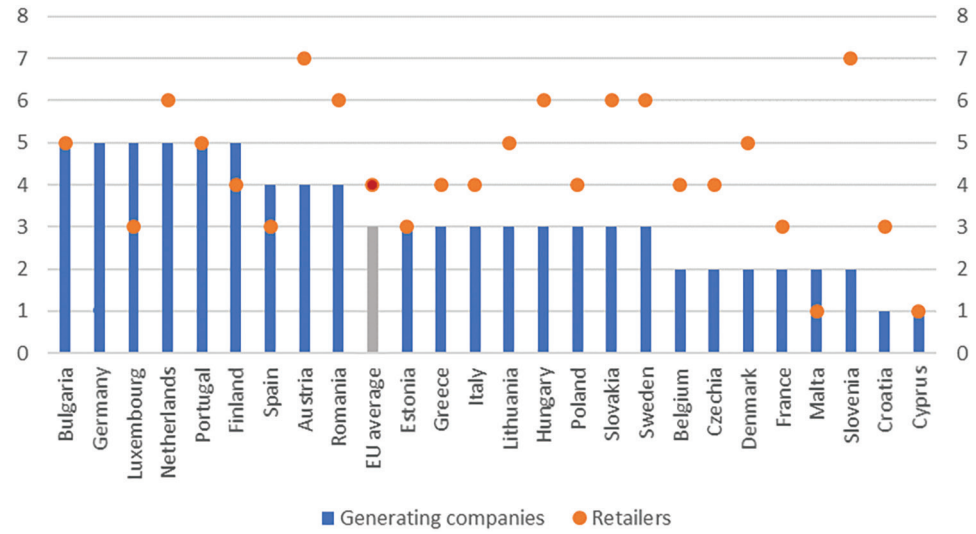
The first typology of energy platforms was drawn up by Kloppenberg and Boekelo (Kloppenburg, Boekelo, 2019) and is based on platforms' physical integration into energy infrastructure as well as users' scope of possible actions within these platforms. Based on the operation of electric utilities in the EU, the framework of the energy platform business model was also defined for the energy transition (Giehl et al., 2020). The framework is a synthesis of classical business model designs. As a result of applying the framework, 69 prototypical business models of the energy sector are identified.

The energy and digital transformations are the main forces for platform business models developed and implemented by electric utilities. The implications of these transformations are emerging platform business models among electric utilities and emerging electricity value chain in the energy sector. The role of electric utilities in shaping this type of business model is significant due to their market share, place in the value chain and ownership structure. The electric utilities cover most elements of the value chain and manage the critical infrastructure necessary for the efficient functioning of the energy sector. This paper reduces the lack of empirical evidence available on platforms in the energy sector.

European electric utilities

An electric utility is a company that mainly generates, distributes and sells electricity according to the unbundling rule. In many cases, the state treasury is the majority shareholder in the ownership structure of electric utilities. Electric utilities provide the framework for generating and delivering electricity to customers. The role of electric utilities remains essential due to the infrastructure they manage and their market share. The number of the largest electricity generating companies in the EU Member States varies from 1 to 5, and for companies selling energy to consumers (retailers), the number ranges from 1 to 7 (Figure 4). Studying the platform business models for electric utilities is vital since it covers most of the energy market.

Figure 4 The number of major electricity generating companies and retailers in 2020



The generating companies and retailers are considered "major" if their market share is at least 5%. In Ireland data is not available. In Germany the number of retailers is not available.

Source: own elaboration based on EUROSTAT.

The electric utilities were selected for analysis based on their annual revenues reported in the financial statements for 2020 (Table 2). The threshold above which the electric utility was considered the largest was set at 1 000 mEUR of annual revenues.

Table 2 The largest European electric utilities selected for primary data collection.

No.	Electric Utility name	Country	Revenues in 2020 (mEUR)
1	EdF S.A. (Électricité de France)	France	69 031
2	Enel SpA	Italy	64 985
3	E. ON SE (incl. Innogy SE)*	Germany	60 944
4	Engie SA	France	55 800
5	Uniper SE	Germany	50 968
6	Fortum Oyj	Finland	49 015
7	Iberdrola SA	Spain	33 145
8	EnBW AG (Energie Baden-Württemberg)	Germany	19 694
9	Vattenfall AB	Sweden	15 026
10	RWE AG	Germany	13 688
11	EDP SA (Energias de Portugal)	Portugal	12 448
12	PGE S.A. (Polska Grupa Energetyczna)	Poland	10 308
13	ČEZ AS	Czechia	8 184
14	SSE plc (Scottish and Southern Energy)**	United Kingdom	7 979
15	Ørsted A/S	Denmark	7 108
16	Acciona SA	Spain	6 472
17	Axpo AG	Switzerland	5 556
18	PPC S.A. (Public Power Corporation)	Greece	4 649
19	Tauron Ekoenergia Sp. z o.o.	Poland	4 587
20	MVM Zrt. (Energetika Zártkörűen Működő Részvénytársaság)	Hungary	4 073
21	Alpiq SE	Switzerland	3 507
22	Verbund AG	Austria	3 234
23	BEH EAD (Bulgarian Energy Holding)	Bulgaria	2 855
24	PKN Orlen Energa S.A.	Poland	2 814
25	Statkraft AS	Norway	1 946
26	Electrica SA	Romania	1 346

* E. ON SE tookover innogy SE in 2019.
** Fiscal year ended in March 2021 and therefore, it was converted with the exchange rate average from 01.04.2019 to 31.03.2020.

Source: own elaboration based on publicly available data.

Platform business models in the energy sector

In Table 3 there are presented the platforms managed by the analysed European utilities.

Table 3. Platforms operated by the most prominent European electric utilities.

No.	Platform name	Electric Utility	Platform purpose
1	Powershift	EdF S.A.	Energy flexibility, optimisation and trading platform that helps turn business' energy into a valuable asset.
2	Agregio	EdF S.A.	Virtual power plant (VPP) that optimises renewable energy generation, demand response and storage assets' flexibilities.
3	Dreev	EdF S.A.	V2G technology provider, whose mission is to lower the cost of electric vehicle ownership while supporting the integration of renewable energy sources, including solar and wind.
4	E2M (Energy 2market)	EdF S.A.	Virtual power plant (VPP) that aggregates flexibility and energy supply from both decentralised generation and consumption systems.
5	Ener2crowd	Enel SpA	Lending crowdfunding platform (also known as Social Lending) that allows a multitude of retail or institutional investors to invest money in energy efficiency, renewable energy and environmental sustainability projects.
6	Enel X	Enel SpA	It offers the support needed for people to live in a smarter, more sustainable way through innovative and scalable solutions that respond to their ever-changing needs.
7	PresAGHO	Enel SpA	E-maintenance platform where predictive models using Artificial Intelligence algorithms are defined and implemented. It gives O&M a powerful tool for efficiently planning and executing inspections and maintenance, thereby significantly increasing safety and savings in terms of time and money.
8	E. ON Optimum	E. ON SE	Cloud-based energy platform that gives customers energy intelligence, which can help to reduce their consumption and costs with ease, enabling them to make faster and better decisions for their business and to meet their sustainability goals.
9	HEMS	E. ON SE	It combines data from all electrical devices within the home – including heating and cooling systems, PV installations, battery storage or chargers for electric vehicles – on a single platform rather than a combination of incompatible individual apps.
10	Data Management Platform	Engie SA	Data Management Platform unites energy, water, and waste data across a global portfolio of sites into one view to deliver powerful insights that help organisations manage their spending and consumption of resources.
11	EGMA	Engie SA	ENGIE's in-house trading platform.
12	e-star	Engie SA	Specifically designed to cater for a pan-European portfolio and based on ENGIE's experience as one of the major actors in the gas market.

No.	Platform name	Electric Utility	Platform purpose
13	Snoop-E	Engie SA	Snoop-E allows smart negotiation. Snoop-E is a digital contract negotiation platform that manages the contract's lifecycle, replacing email exchanges.
14	EnergyScan	Engie SA	It provides economic research to manage clients' assets and investments.
15	TiP	Engie SA	TiP is designed as an integrated digital solution "as a service" gathering the comprehensive expertise of short-term power teams.
16	The Energy Origin (TEO)	Engie SA	The electricity matching & blockchain certification platform. It provides an autonomous device plugged into any type of meter on production and consumption sites to collect data in real-time instantly. With the device, the data is then signed and can be registered on any blockchain for decentralised applications.
17	WattsOn	Engie SA	The Platform allows the Client to access its data via its Authorised Representatives.
18	Operaite	Uniper SE	Neural network-based tool that directly operates asset processes such as the combustion in waste-to-energy or biomass-to-energy.
19	SaaS Platform	Fortum Oyj	SaaS Platform for EV Charging Network Management
20	Fortum Online	Fortum Oyj	The portal that allows for real-time energy consumption tracking and comparing it with previous estimates.
21	Virtual Power Plant	EnBW AG	It bundles decentrally generated energy into a virtual power plant and sells it.
22	PGE eSklep	PGE S.A.	The platform for buying the products of PGE's partners.
23	Driivz	ČEZ AS	EV charging management system for the entire ČEZ electromobility network.
24	SSE Enhance	SSE plc	Smart grid, aggregation, and trading platform enabling large energy users to earn money from balancing supply and demand.
25	Retail Service Platform	Ørsted A/S	Retail Service Platform offers energy supply companies a wealth of trading and risk management solutions.
26	GreenH2chain	Acciona SA	It allows customers to verify and visualise the entire green hydrogen value chain in real-time and from anywhere in the world.
27	Platforma Integracyjna	Tauron Ekoenergia Sp. z o.o.	It allows the aggregation of the generation sources such as RES and energy storage and selected categories of controllable loads, e.g. HVAC, to regulate the electricity generation and consumption.
28	POI	PKN Orlen Energa S.A.	It allows customers to purchase electricity and gas from the wholesale market.

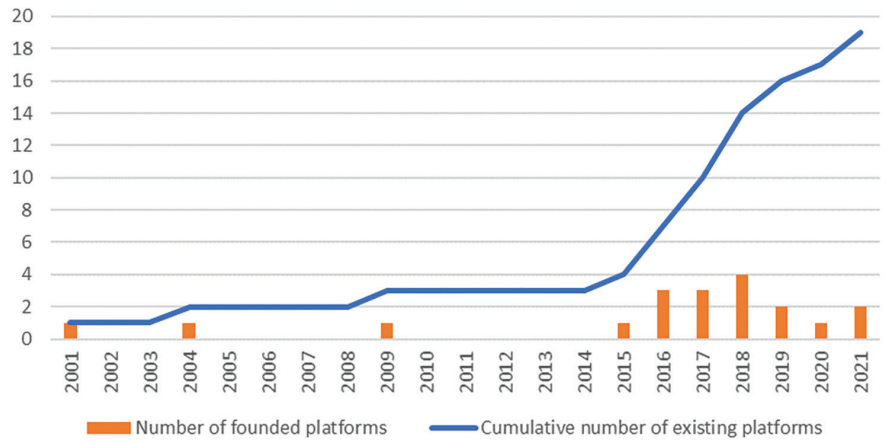
Source: own elaboration based on publicly available data.

Most platforms, as many as 12 have been identified in France. This number is mainly due to the innovative approach to the business models of French electric utilities such as EdF and ENGIE. Germany is the second country with the most significant number of platforms, with 6 platforms managed by electric utilities such as E. ON, EnBW and Uniper. In countries such as the UK, Italy and Poland, there are

3 platforms, each managed by national electric utilities. The countries with 2 platforms are Sweden, Finland, the Netherlands and Belgium. One platform was identified in Denmark, Spain and Czechia.

The majority of identified platforms were founded after 2015 (Figure 5). The highest dynamics of the increase in new platforms were observed in 2015–2019. The most technologically advanced platforms are implemented by the electric utilities from developed countries i.e. EdF, Engie, Enel or E. ON. As a consequence, they may allow for deeper energy and digital transformation in their countries of origin.

Figure 5 The number of founded platforms and the cumulative number of existing platforms



* Platforms without the specified year of the foundation are not presented.

Source: own elaboration based on publicly available data.

The identified prototypes were assigned to each existing platform listed in Table 3. The business model prototypes and classes represent a snapshot of the current energy sector. Current classes might no longer exist in the long run, while new classes might emerge. As a result of the analysis, 28 platforms (Table 3) managed by European electric utilities (Table 2) were identified. This paper presents the current status of platform business models with 9 unique classes of such (Table 4) in the EU.

The largest class of platform business models is the Trading platform and it contains 25% of all analysed existing platforms. Two classes of the same size contribute 14% each: the Virtual Power Plant (VPP) and Vehicle to Grid (V2G) platform. The following two classes, also with the same number of platforms, with 11% each, are the Information platform and the Smart Contract Platform. Analytics platform and Smart Power Plant platform contain two platforms each, which is 7% of the contribu-

tion in the total number of analysed platforms. The minor classes of 4% contribution each are the Funding platform and Smart Home platform. Only one existing platform, PGE sklep does not fit any class due to its unique character not related to the energy sector value chain. The definitions of classes and existing examples of platforms are presented in Table 4. The definitions are developed based on the activities and purposes of existing platforms.

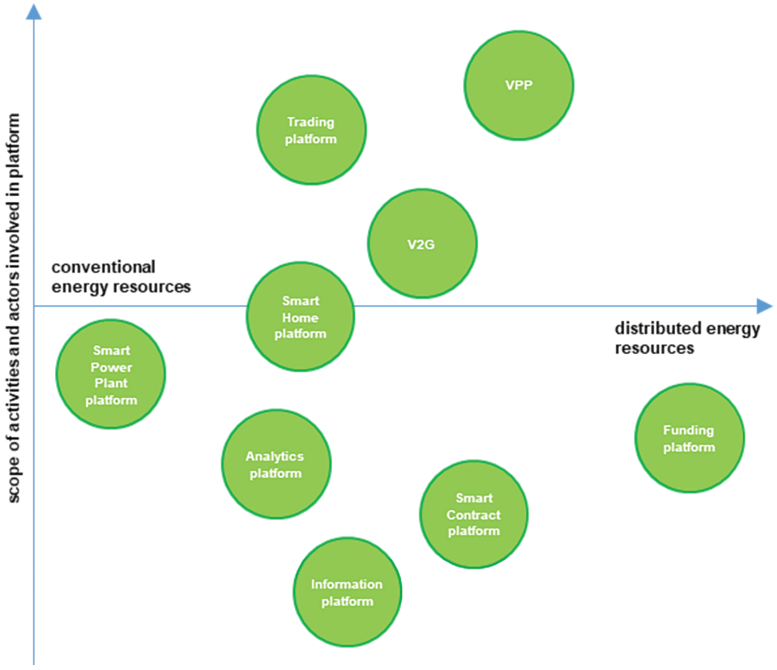
Table 4 Definitions of energy platform classes and existing examples of platforms in the EU.

No.	Class name	Definition	Existing platforms (electric utility)
1	Trading platform	Allows its users to trade energy products (physical and financial instruments) and participate in energy flexibility markets, e.g. capacity, balancing, and demand-side response	(1) Powershift (EdF) (2) EGMA (Engie) (3) e-star (Engie) (4) TiP (Engie) (5) SSE Enhance (SSE) (6) Retail Service Platform (Ørsted) (7) Platforma Ofert Indeksowanych (POI) (PKN Orlen Energa)
2	Virtual Power Plant (VPP)	Aggregates and optimises the DER together with conventional power plants	(1) Agregio (EdF) (2) E2M (EdF) (3) Virtual Power Plant (EnBW) (4) Platforma Integracyjna (TAURON)
3	Vehicle to Grid (V2G) platform	EV charging management system that integrates EV charging stations with RES and enables charging EV battery and discharging stored energy back to the grid	(1) Dreev (EdF) (2) Enel X (Enel) (3) SaaS Platform (Fortum) (4) Driivz (ČEZ)
4	Funding platform	A crowdfunding platform that facilitates investments in RES projects	(1) Ener2crowd (Enel)
5	Informa-tion platform	Provides information on energy consumption, billing details and market data to its users	(1) EnergyScan (Engie) (2) WattsOn (Engie) (3) Fortum Online (Fortum)
6	Analytics platform	Provides energy data analysis concerning energy usage costs and efficiency	(1) E. ON Optimum (E. ON) (2) Data Management Platform (Engie)
7	Smart Power Plant platform	A platform that provides predictive maintenance models or asset processes operations, can be based on AI	(1) PresAGHO (Enel) (2) Operaite (Uniper)
8	Smart Home platform	Combining home electrical devices to increase energy efficiency and reduce energy usage costs, it can be based on the IoT	(1) HEMS (E. ON)
9	Smart Contract platform	Allow smart contracting of energy-related products or guarantees of origin and can be based on blockchain	(1) Snoop-E (Engie) (2) The Energy Origin (TEO) (Engie) (3) GreenH2chain (Acciona)

Source: own elaboration based on publicly available data.

Platform classes differ in using conventional and distributed assets, and the scope of activities users can perform (Figure 5). The Smart Power Plant platform is dedicated to conventional generation sources, while platform funding is used to finance RES. The other classes use both conventional and distributed energy resources in varying proportions. The classes differ significantly in the scope of possible activities. The VPP and the Trading platforms allow users a broad spectrum of activity. On the other hand, the Information platform and the Smart contract platform have a minimal range of possible activities. The assessment of the technology used in the platforms, depending on their class, deserves attention for further research.

Figure 6 The differences between platform classes concerning the scope of activities and actors as well as conventional and distributed energy resources.



Source: own elaboration based on publicly available data.

Currently, no electric utility in the EU would not include green and digital transformation in its strategy. Engie is the leader in digital transformation in the European energy sector. As stated in its strategy, "Engie aims to transform the physical world of energy through digital technology by providing our clients with the best digital tools to access our energy services and support them in making their digital transformation a success." Engie developed and implemented the most, as many as 8 platforms

among those described in this article. Among Engie's platforms, there are the Trading platforms (EGMA, e-star), the Information platforms (WattsOn), the Analytics platforms (Data Management Platform), and the Smart Contract platform (Snoop-E). Engie informs in its strategy that it develops and uses blockchain and IoT technology in its platforms. Electric utilities strategies are crucial in the development of platform business models. Without entering into the strategy the need to develop new business models in the spirit of digital and green transformation, it would not be possible to implement platforms by electric utilities.

The need to develop digital platforms by electric utilities results mainly from the need to develop technologies that would optimise the operations of intermitted RES. It would also fit into market trends and customer expectations. RES creates a problem related to balancing the power grid. It results from the limited possibilities of using the surplus of electricity generated from RES and securing its supply in the event of a lack of its generation from RES. The solution for such a problem can be a Virtual Power Plant (VPP). VPP, such as Agregio (EdF), E2M (EdF), Virtual Power Plant (EnBW), and Platforma Integracyjna (TAURON), optimises RES generation by aggregating the capacity and balancing supply and demand. Sector coupling deserves attention if electric utilities adapt to market trends. The examples here are the V2G platforms, i.e. Dreev (EdF), Enel X (Enel), SaaS Platform (Fortum), Driivz (ČEZ) and the Smart Home platforms, i.e. HEMS (E. ON), which link the energy sector with the transport and housing sectors respectively.

Regarding customer expectations, all platforms (excluding Smart Power Plant platforms) described in this article meet them to a greater or lesser degree. One of the first digital platforms in the sector was the Information platforms, e.g. Fortum Online, followed by the Analytics platforms, e.g. E. ON Optimum (E. ON). These platforms do not require advanced technologies such as AI, blockchain or IoT. Blockchain is used mainly in the Smart Contract platforms, e.g. Snoop-E (Engie) or TEO (Engie), which respond to customer expectations that it is possible to conclude contracts remotely, safely and quickly. The Internet of Things (IoT) is, in particular, the domain of the V2G platforms and Smart Home platforms mentioned above. At the same time, Artificial Intelligence (AI) is used in the Smart Power Plant platforms, e.g. PresAGHO (Enel) or Operaite (Uniper). The Smart Power Plant platforms emerged from the need for electric utilities to meet energy efficiency targets and the need to forecast faults and keep conventional sources running smoothly.

When it comes to the consequences for electric utilities stemming from the platform implementation, first of all, these are new business models that can be a source of income. The electric utilities do not provide detailed information on revenue models and the value of revenues from individual platforms. Nevertheless, they indicate that access to some platforms is paid on a subscription fee basis.

The relationship between the functionalities of platforms and the value generated for the leader should be the subject of further research. New business model platforms are the basis for developing the emerging electricity value chain presented in Figure 3. They enable information flow between the electric utilities and their customers at all value chain elements.

Moreover, they contribute to balancing the electricity flow in the grid, e.g. Powershift (EdF). Balancing the electricity flow contributes to developing RES and DER connected to the grid. A significant consequence of implementing platforms by electric utilities is the active inclusion of customers in the energy market. The prosumers can trade the electricity generated in their RES through the Trading platform, e.g. solar panels and earn revenue. The Trading platforms are additional means for electric utilities to increase electricity sales from their RES and reduce CO_2 emissions. The VPP allows electric utilities to aggregate flexibility and energy supply from both decentralised generation and consumption systems and trade in reserve and frequency energy markets. V2G platforms enable the customers to lower the cost of owning the EV fleet. On the other hand, the electric utilities can optimise electricity use by electric vehicles (EV) as energy storage, e.g. to reinject electricity from the connected EV fleet to the charging point into the building when they are not in use (during peak consumption periods). Other classes of platforms dedicated to the particular needs of customers strengthen the collaboration between electric utilities and their customers as well as enable the offering of additional services.

In the implementation of platform business models, an important role is played by both macro- and microeconomic factors, between which there are interdependencies.

The former should include the regulations of the energy sector, which are the most remarkable stimulator of the transformation towards climate neutrality and enablers of this transformation. The most prominent are changes in the EU law stemming from European Green Deal and Fit for 55.

Extraordinary events in the macroeconomic environment are also not without significance. Most of the platforms described in this article were created during the years of prosperity in Europe from 2015 to 2019 (Figure 4). The COVID-19 pandemic that hit Europe in 2020 slightly reduced the dynamics of the platform's development in the energy sector. The crisis triggered by the COVID-19 pandemic has accelerated the digital transformation, and we can expect the energy sector to follow this trend along with a regulatory-driven energy transition. The aftermath of this crisis is the rise in the prices of fossil fuels such as coal and gas.

The war on Ukraine that broke out in 2022 accelerated the growth of fossil fuel prices and significantly increased their supply risk due to the sanctions imposed on Russia. The pandemic and the war do not go unnoticed in the economy and will impact the platform business model development. Currently, Europe is experiencing an eco-

nomic slowdown and a significant increase in inflation. These negative macroeconomic factors will undoubtedly lower the external financing opportunities for digital energy projects such as the platforms.

Many financial mechanisms at the UE and member state levels support the energy and digital transformations. Some of them have been used by the energy sector for years, incl. Modernisation or Innovation Fund. To mitigate the economic and social impact of the coronavirus pandemic European Commission (EC) introduced the Recovery and Resilience Facility (RRF). It aims to help the EU achieve its climate neutrality target by 2050 and set Europe on the path of the digital transition. It assumes targets of 37% for climate and 20% for digital spending. The RRF is integrated with the REPowerEU Plan, which is the Commission's response to the socio-economic crisis and energy market disruption caused by Russia's invasion of Ukraine. This Plan aims to repower the EU and reduce the EU's reliance on Russian fossil fuels. Planned and available funds in the EU and a reduction in the supply of fossil fuels will undoubtedly accelerate twin transformations: climate neutrality and digital transition.

In the context of microeconomic factors, attention should be paid to the financial condition of electric utilities, which will not be stable due to the economic crisis. However, implementing the electric utilities strategies to achieve climate neutrality is gaining more and more importance. An important area of research is the value for platform participants and revenue for the leader that can be expected from the business models.

Conclusions

This paper shows that electric utilities have actively employed novel energy business models to meet customers' and regulators' needs. Electric utilities have been implementing platform business models in Europe since the beginning of the XXI century. The main forces for platform business models developed and implemented by electric utilities are energy and digital transformations. The implications of these transformations are emerging platform business models among electric utilities and emerging electricity value chain in the energy sector. The role of electric utilities in shaping this type of business model is significant due to their market share, place in the value chain and ownership structure. The electric utilities cover most elements of the value chain and manage the critical infrastructure necessary for the proper functioning of the energy sector.

This paper refines the platform classes in the energy sector and identifies new prototypes that characterise them (Giehl et al., 2020). On the other hand, this analysis extends the typology of energy platforms drawn up by Kloppenberg and Boekelo (Kloppenburg, Boekelo, 2019). The study considers not only the activities performed

within the platform, but also its actors and the assets involved in these activities. First of all, platforms allow their users to engage in activities performed so far in the energy markets, e.g. peer-to-peer trading. Secondly, the platform gives more control to its users over the electricity they consume, e.g. selecting electricity from RES via smart contracts. Finally, the platforms create tensions for energy citizenship, e.g., the participation of citizens in the energy market through solar panels, smart meters, and electric vehicles can put new demands on electric utilities and policymakers.

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