Leveraging Enterprise Architecture for Digital Transformation in Energy and Regulated Sectors: A Cross-Sector Perspective – The Czech Republic Case Study

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Abstract: This study investigates Enterprise Architecture (EA) as a strategic enabler of digital transformation (DT) and digital maturity (DM) within smart energy systems, focusing on Czech energy utilities operating under stringent regulatory frameworks. EA is conceptualized as a socio-technical coordination mechanism that aligns business and IT, integrates operational technology (OT) with digital platforms, and supports governance through standards and modelling languages such as TOGAF and ArchiMate. A mixed-method design was applied, combining a cross-sector survey with semi-structured interviews to capture adoption patterns, inhibitors, and tool practices across energy, finance, and public administration. Results reveal that energy utilities lead in EA maturity, particularly in ArchiMate-based TO-BE modeling, reflecting their role in grid modernization, renewable integration, and operational resilience within complex energy systems. Qualitative insights highlight a shared governance core, encompassing business-IT alignment, decision rights, and change management, while sector-specific differences emerge in areas such as interfaces, cultural readiness, and portfolio linkages. The results confirm EA's dual role as a governance instrument and communication platform, enabling traceable decisions under regulatory constraints and fostering stakeholder engagement. Implications for practice include the need for configurable EA frameworks integrated with project and program management to accelerate smart grid initiatives and sustainability objectives across energy systems. Future research should investigate the causal relationships between EA maturity, stakeholder effectiveness, and DT success metrics in diverse regulatory environments.

Keywords: Enterprise architecture, Business and IT alignment, ArchiMate boundary objects, Digital transformation, Energy sector, Stakeholder management.

1. INTRODUCTION

The digital transformation (DT) of energy systems—characterized by smart grids, high penetration of distributed energy resources (DER), real-time flexibility markets, and heightened cybersecurity requirements—has intensified the need for coherent and traceable governance across utility enterprises. These dynamics unfold under stringent regulatory obligations and reliability imperatives, while the convergence of information technology (IT) and operational technology (OT) reshapes how utilities plan, operate, and modernize critical infrastructures. In such contexts, organizations require a systematic capability to align strategic intent with portfolio execution, ensure compliance, and maintain operational resilience.

Enterprise Architecture (EA) has reemerged as a central governance and design capability for organizations undergoing digital transformation (DT), particularly in regulated, asset-intensive domains such as energy. DT can be viewed as an organization-level process in which digital technologies trigger strategic responses and structural changes to create new value pathways. In this perspective, EA functions as a socio-technical coordination mechanism that connects stakeholder concerns with architecture descriptions and decisions across business, application, data, technology, and infrastructure layers [1, 2]. The digitalization of energy systems necessitates coordination among IT/OT integration (*e.g.* smart-grid governance within regulated energy systems) and business strategy, all while adhering to strict regulatory, safety, and reliability constraints. EA provides a structured mechanism for representing AS-IS constraints and designing TO-BE target states, aligning stakeholders and investments across portfolios, while supporting smart grids, energy systems, and sustainability initiatives. This paper examines how EA, ArchiMate modeling, and boundary objects contribute to digital transformation (DT) and digital maturity (DM) within Czech energy utilities, situating sectoral patterns within the context of finance and public administration.

Beyond modelling, contemporary EA practice benefits from standardization and method guidance. The TOGAF® Standard, 10th Edition, emphasizes configurable guidance for agile enterprises and DT programs, while maintaining enduring concepts and governance focus [3, 4]. In parallel, the ArchiMate® 3.2 Specification provides an open, tool-supported modelling language with layers, relationships, and migration concepts that map well to AS IS/TO BE transitions. These instruments combine to support systematic architecture development, visualization, and traceable decision making required by ISO/IEC/IEEE

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42010 for stakeholder-oriented architecture descriptions, while enabling IT/OT integration for smart grids, energy systems, DER, and sustainability objectives.

From a strategy perspective, the link between EA and business execution is long established: EA—grounded in an explicit operating model—builds a reusable platform for profitable growth, speed, and coherence across initiatives [5]. In the energy sector, where modernization necessitates the interoperability of IT/OT, cybersecurity in smart grid expansion is one of the preferred energy system models (incl. DER). The integration of distributed resources, governance models, and policy innovations intersects with enterprise design choices.

This study builds on prior research by presenting findings from a mixed-method investigation into the role of EA in supporting DT and DM within Czech energy enterprises. The analysis combines qualitative insights from (i) quantitative evidence from a cross-sector survey and (ii) qualitative semi-structured interviews with non-EA/IT stakeholders, enabling a comparative perspective across regulated domains such as finance and public administration. The survey results reveal sector-specific inhibitors and adoption patterns, with the energy sector demonstrating the highest EA and ArchiMate adoption, accompanied by a strong emphasis on TO-BE modeling [3, 4].

The article is structured as follows: the literature review synthesizes theoretical perspectives on EA as a socio-technical coordination mechanism and its interplay with DT and DM, emphasizing the relevance of governance frameworks such as TOGAF and modeling languages like ArchiMate for asset-intensive industries [6, 7]. The methodology section outlines the design of a mixed-method approach, combining interviews and survey data to capture inhibitors to business-IT alignment and EA boundary objects adoption practices. Results detail EA tool usage, modeling practices, and governance challenges, while the discussion interprets these findings in light of regulatory obligations and organizational complexity (smart-grid and energy system modernization covering DER), proposing actionable recommendations for integrating EA governance with project and program management [8, 9].

By situating EA artifacts as boundary objects that mediate stakeholder concerns and accelerate DM, this study contributes to the growing body of knowledge on EA's role in enabling strategic coherence and adaptability in energy sector digitalization [3]. Future research directions include establishing empirical links between EA maturity and DT success metrics in regulated, asset-intensive environments, with particular emphasis on IT/OT integration, energy system governance, smart grids, and sustainability outcomes.

2. LITERATURE REVIEW

A. Enterprise Architecture

EA is conceptualized as a practice centered on a coherent set of documents—often referred to as artifacts—that describe various organizational domains, including business processes, applications, data, infrastructure, and security, from an integrated business and IT perspective. These artifacts serve as a communication medium between diverse stakeholders, enabling structured dialogue for strategic planning, operational alignment, and IT governance. Rather than being a rigid model, EA is positioned as a pragmatic approach that facilitates decision-making and organizational evolution through documentation that captures both current (AS-IS) and future (TO-BE) states. EA should not be understood as analogous to physical architecture but as a metaphorical umbrella term for practices that support business-IT alignment and informed decision-making. The modern concept of EA critiques traditional linear models—such as the four-step approach of current state, future state, roadmap, and implementation—as inadequate for dynamic socio-technical environments. Instead, many EA practitioners advocate for an evidence-based, practice-oriented perspective, grounded in research and real-world organizational practices, where EA artifacts, processes, and governance bodies collectively enable strategic coherence and adaptability [10, 11].

The liberalization of electricity markets has transformed the organizational structures of utilities and the operational dynamics of power systems. To address these complexities, EA provides a structured approach for aligning business and IT domains, ensuring interoperability across diverse processes and DER. This alignment enables the timely and accurate delivery of information to system operators, supporting integrated decision-making in smart grids and modern energy systems for DER, which are supported by IT/OT [12].

B. Digital Transformation

In the past few decades, we have seen the' rising penetration of digital technologies in our lives. They influence many aspects of social & professional life. This type of penetration, with its essential changes and impacts on lives, is often referred to as digital transformation (DT). An evolutionary process that leverages digital capabilities and technologies to

enable business models, operational processes, and customer experiences, thereby creating value [13].

DT integrates digital technology into all business areas, fundamentally changing how businesses operate and deliver customer value. Digital transformation is a combination of multiple digitalisation projects with the intention of "customer-driven end-to-end strategic business transformation that requires organisation-level changes to core competency". Many scholars define the opportunities created by digitisation in terms of organisational patterns and cultural barriers, and transform existing business models, socioeconomic cultures, and legal and policy measures. DT has been increasingly focused on by researchers, practitioners, and politicians [14].

Although DT in energy companies involves several technological challenges, they should be conducted with emphasis on the human being since cultural changes are expected in all stakeholders [15]. DT involves changes in an organization's business model resulting from the adoption of emerging digital technologies, which in turn lead to changes in organizational structures, products, or services [16]. The DT of the university education system should have a broader focus and must include the modernization of corporate IT architecture management, which could contribute to structuring the efforts for innovation in education [17].

C. Digital Maturity

The term "digital maturity" is closely related to digital transformation. We can say that digital maturity is the final stage of DT, which companies aspire to achieve. Those who have achieved such DM have now witnessed significant improvements in the company's operations and increased customer satisfaction [14, 18].

Maintaining achieved digital maturity (DM) and advancing to higher levels presents significant challenges. In the public sector, digital transformation (DT) seeks to deliver tangible improvements in citizens' lives, distinguishing it from IT-enabled change focused primarily on operational efficiency [2, 19, 20]. DM extends beyond a technological perspective; it reflects not only IT-driven task execution and information flow but also a managerial dimension, capturing progress in DT initiatives through changes in products, services, processes, skills, culture, and organizational capabilities for managing change [20].

Much more difficult circumstances than starting DT are visible to keep the achieved level of DM and smoothly progress to the next upper level. On the other hand, DM goes beyond a merely technological interpretation, simply reflecting the extent to which an organization performs tasks and handles information flows by IT but also reflects a managerial interpretation describing what a company has already achieved in terms of performing DT efforts, including changes in products, services, processes, skills, culture, and abilities regarding the mastery of change processes [21].

The deployment of smart grids, interconnected and interoperable energy trading and management systems, as well as the exploitation of the potential of artificial intelligence, blockchain, and other digital technologies, can completely change the position and roles played by suppliers and consumers [22].

D. Boundary Objects

Boundary objects are artifacts that enable collaboration across heterogeneous communities by accommodating divergent expertise and perspectives. Within EA, these artifacts facilitate communication between business and IT stakeholders, promoting alignment and a shared understanding. Kotusev and Kurnia identify five categories of EA artifacts that function as boundary objects, distinguished by their informational content, usage context, target audience, and capacity for syntactic, semantic, and pragmatic boundary spanning. The concept of duality further emphasizes interpretive flexibility, highlighting implicit and explicit mechanisms that allow artifacts to support multiple stakeholder interpretations. Their study provides a qualitative analysis of EA artifacts as boundary objects, advancing theoretical and practical insights into their role within EA governance and digital transformation [3, 23].

E. Enterprise Architecture Framework TOGAF

Foundational contributions frame EA as a route to consistent execution through standardization and integration, aligned with an explicit operating model [6]. Subsequent TOGAF material emphasizes configurable adoption, stakeholder engagement, and integration with portfolio/program management—capabilities frequently cited as prerequisites for DT at scale [4]. The Architecture Development Method (ADM) in [4] provides a structured, iterative framework for creating and maintaining enterprise architectures. It consists of sequential phases—from Preliminary and Architecture Vision through Business, Data, Application, and Technology architectures to Implementation and Change Management—ensuring alignment with organizational strategy and governance. ADM's

adaptability supports continuous refinement, making it a cornerstone for enterprise architecture practice [4].

F. Graphical Notation Language ArchiMate

ArchiMate® 3.2 specifies a layered metamodel (motivation, strategy, business, application, technology, implementation/migration) and viewpoint mechanism that supports AS IS and TO BE modelling, traceability, and stakeholder-specific visualizations [4, 7]. In organizational communication theory, such visual artefacts can operate as boundary objects—simultaneously robust and plastic—enabling collaboration across heterogeneous communities without requiring full consensus. This is particularly relevant for energy utilities, where operations, engineering, IT, compliance, and market functions must coordinate closely around grid modernization or asset digitization programs.

ArchiMate is crucial for effective communication within EA practice, as it captures key phases of the TOGAF ADM cycle and includes motivational and implementation extensions. It interlinks elements across layers, providing a comprehensive organizational view and facilitating impact analysis. Neither oral nor written descriptions effectively convey EA; graphical notation provides superior visualization. ArchiMate, widely adopted in recent years, structures EA into four layers: Strategy, Business, Application, and Technology. The strategy layer models capabilities, resources, and actions that support an organization's strategy. The business layer represents processes, services, and functions, while the application layer encompasses software that supports business operations. The technology layer covers infrastructure and communication [7]. EA modelling involves two perspectives: AS-IS (current state) and TO-BE (future state). Although AS-IS is often overlooked, both states are essential for designing scalable, adaptable initiatives. A holistic EA approach enables organizations to plan long-term transformations through programs, projects, and portfolios within defined constraints (scope, quality, resources), ensuring alignment with strategic objectives [24].

G. EA Software Tools

Gartner defines EA tools as platforms that enable organizations to model and manage interdependencies across applications, capabilities, processes, roles, data, and technology systems. These tools serve as centralized repositories for storing artifacts and viewpoints that reflect current and future enterprise structures. They support modeling IT and business elements, strategic decision-making, and digital transformation efforts [25].

Enterprise Architecture tools provide a unified platform for organizational design and governance by offering centralized repositories with version control, integrated modeling of capabilities, processes, roles, and technologies, and seamless connections to product management, configuration management databases, process mining, and agile planning systems. They incorporate advanced analytics for gap identification, risk evaluation, and opportunity assessment, support extensibility through custom metamodels and domain-specific rules, deliver visualization via dashboards, heatmaps, and scenario modeling, and ensure secure configuration and role-based access management [25].

H. Project & Program Management

EA functions as a structured, holistic, and future-oriented instrument for enhancing project and program management (Pj&PgM) [8]. Pj&PgM supports the implementation of EA's strategic objectives through DT initiatives [26]. Pj&PgM is a disciplined approach encompassing initiation, planning, execution, monitoring, and closure to achieve project goals within constraints of time, cost, resources, and quality [8]. It involves coordination of team management, resource allocation, communication, and risk mitigation. Prominent methodologies include PRINCE2 (UK), PMI's PMBOK (USA), and IPMA's ICB (Switzerland), each documented in formal guidelines and linked to professional certification systems. PMBOK and PRINCE2 remain the most widely adopted standards among researchers and practitioners [9]. ISO 21500, introduced in 2012, further standardized project management globally. Agile approaches—such as APM and Scrum—are increasingly applied in IT and EA development contexts, emphasizing flexibility and iterative delivery [27]. While some studies address Pj&PgM in strategic alignment without EA [21], contemporary DT initiatives increasingly integrate EA's holistic perspective, encompassing AS-IS and TO-BE states [21, 28, 29].

I. Digital Transformation in the Energy Sector

Energy transition and smart grid modernization raise governance issues (cybersecurity, data privacy, interoperability, market design) that interact with enterprise architectures. EA governance can internalize external constraints, such as architectural principles and requirements, ensuring that portfolio decisions and migration sequencing respect regulatory and reliability obligations. Digitalization is driving significant changes in the energy sector, fostering innovation and reshaping business models. Future drivers of the energy market will establish a digital backbone that supports the transition from fossil fuels to renewable energy, thereby creating an energy

system interconnected with our personal and local ecosystems [30]. Digitalisation plays a key role in implementing the new model of the 3Ds of energy development. Effective digitalization will enable the development of increasingly advanced technologies, allowing for the diversified production of energy and the utilization of decentralized renewable sources [22].

DT is defined as 'a new development in the use of digital artifacts, systems, and symbols within and around organizations' and has been considered one of the main drivers of economic growth and sustainable development in today's business world [31]. The power industry is moving towards a more decentralized model, where electricity is generated from renewable sources and distributed through microgrids and smart grids, supported by digital technologies such as IoT, AI, and Big Data analytics [32].

3. METHODOLOGY

The energy sector, particularly power supply and distribution, faces unique challenges in achieving DM due to its reliance on complex physical infrastructure and legacy systems. EA facilitates alignment between strategic, technological, and physical layers, enabling integration of smart grids, digital monitoring, and renewable energy sources. Despite progress, barriers such as regulatory compliance and competence gaps persist. The same is valid for the highest adoption of holistic EA to support Pj&PgM of strategic DT initiatives in the Czech Republic.

Based on the following, research questions were formulated. **RQ#1:** How does the adoption of EA practices and ArchiMate modeling influence DT and DM in Czech energy enterprises compared to other regulated sectors? This research question investigates the role of EA as an enabler of DT and DM, considering sector-specific adoption patterns and comparative insights. **RQ#2:** What organizational and governance factors act as inhibitors to effective EA implementation for achieving business-IT alignment and TO-BE modeling in large-scale DT initiatives within the energy sector? This research question focuses on barriers such as regulatory compliance, competence gaps, and integration challenges in project and program management. **RQ#3:** How does the selection and utilization of EA modeling tools and ArchiMate notation influence the effectiveness of TO-BE modeling and strategic alignment in DT initiatives within the Czech energy sector? The centre of this research question is on the impact of tool choice and modeling practices on EA and DT success.

To address the research questions, the study employed a mixed-methods design that combined (i) a quantitative survey with (ii) qualitative semi-structured interviews.

A. Quantitative Survey

The survey captured EA adoption, ArchiMate usage for AS-IS and TO-BE modeling, and EA tool selection. It was administered online via Google Forms between April and June 2023, following a pilot test and refinement. Invitations (N = 105) yielded 55 valid responses from professionals in energy, finance, and public administration sectors, with data on role, sector, and enterprise size. The qualitative component consisted of narrative interviews with non-EA and non-IT stakeholders from three industries: (i) energy & utilities, (ii) finance/banking/insurance, and public administration.

The survey was distributed to 105 respondents (the demographic of respondents is presented in Tables **1** and **2**), yielding 55 valid responses, which corresponds to a response rate of 52%. Participants were recruited through electronic channels, and the sample included respondents from different regions. Despite these efforts, the sample does not accurately reflect the entire Czech energy management sector.

The distribution of respondents by their job title is illustrated in Table **1**. To achieve this level of response, participation in the survey was encouraged through diplomatic outreach via personal and social network connections. The respondents responded to the emergency in a friendly and understanding manner, demonstrating a clear understanding of the purpose of the questionnaire survey. The target group covered the industry sector shown in Table **2**.

Table 1: Respondents by Job Title

Job title	#	%
Chief Executive Officer (non EA & non-IT stakeholder)	2	3,6
Delivery director (non EA & non-IT stakeholder)	1	1,8
Enterprise Architect	7	12,8
IT Administrator	10	18,2
IT Analyst	4	7,3
IT Consultant	1	1,8
IT Coordinator	7	12,7
IT Director	16	29,1
IT Engineer	2	3,6
IT Specialist	4	7,3
Project manager (non EA & non-IT stakeholder)	1	1,8
Total	**55**	**100**

The electronic distribution method may have introduced bias by favoring respondents with reliable internet access and higher digital literacy. However, internet availability among respondents is high. And, the participation was voluntary, which could result in self-selection bias and limit the generalizability of the findings.

Table 2: Enterprise Per Industry Sector

Industry sector	#	%
Energy (power supply)	13	23,6
Finance/banking/insurance	23	41,8
Public administration	19	34,6
Total	**55**	**100,0**

B. Qualitative Semi-Structured Interviews

The narrative semi-structured interview approach was used to gather in-depth insights from key stakeholders engaged in DT initiatives, supported by EA boundary objects, specifically ArchiMate. Semi-structured interviews combined a flexible interview guide with open-ended questions, allowing for the exploration of emerging themes while maintaining consistency across participants [33, 34]. One participant per industry was selected for experience in strategic planning and DT program initiation. Interviews, conducted in person or remotely during Spring and Summer 2024, lasted 40–50 minutes and were recorded and transcribed for thematic analysis. The narrative semi-structured interviews were conducted more than a year after the survey to allow for a comprehensive analysis of the quantitative findings, ensure that participants had accumulated sufficient experience with ongoing DT initiatives for richer insights, and strengthen methodological triangulation by integrating longitudinal perspectives from both research phases. This design enabled triangulation of sectoral adoption patterns, inhibitors, and tool practices in regulated, asset-intensive contexts. All sessions were audio-recorded, transcribed verbatim, and anonymized prior to analysis. The interview protocol addressed the following nine thematic areas, according to [35]: (1) Significant experiences and EA-related challenges, (2) Contribution of EA to strategic goals and process improvements (Business Architecture), (3) Role of strategic planning and differentiation from project management (Program Management), (4) Initiative delivery, methodologies used, and overcoming project challenges (Project Management), (5) Alignment strategies, misunderstandings, and associated benefits (Business–ICT Alignment), (6) Horizontal and vertical communication and its impact on decision-making (Information Flow), (7) Stakeholder engagement strategies, involvement levels, and influence on outcomes (Stakeholder Management), (8) Practical use of EA boundary objects (ArchiMate)—visualization, implementation, and strategy and (9) Interrelationships between EA, ArchiMate, and DT across all aforementioned areas. Responses were analyzed using thematic coding to identify patterns, interconnections, and sector-specific interpretations. This rigorous qualitative procedure ensures a nuanced understanding of how EA and ArchiMate are operationalized in DT initiatives across the three sectors mentioned in the Czech Republic: (I) Public Administration (PA), a key institution responsible for collecting, analyzing, and publishing statistical data in the Czech Republic. It employs approximately 1,200 staff members and manages agendas such as demographics, economics, social statistics, agriculture, the environment, and elections. Its activities are defined by national legislation on statistical services and annual decrees on statistical programs. (II) Finance and Banking (F&B): A major banking institution providing comprehensive financial services to individuals and businesses. It is part of an international banking group and employs around 7,400 staff. Its operations include deposit and loan services and are regulated by national banking legislation. (III) Energy and Utilities (E&U): A significant company within a large energy group, focusing on the sale of electricity and gas to end customers in Czechia. Established in the mid-2000s, it offers a wide range of energy services, including consultancy and customer support. It employs approximately 1,200 staff and operates under national legislation governing business corporations.

4. RESULTS

A. Quantitative Survey Results

Energy & Utilities (E&U) leads ArchiMate usage with 16 of 23 respondents (69.56%), followed by Public Administration (PA) with 12 of 19 (63.17%) and Finance/Banking (F&B) with 8 of 13 (61.54%). The gap between E&U and PA is 6.39 percentage points (pp), while the gap between E&U and F&B is 8.02 pp, indicating moderate dispersion rather than extreme sectoral divergence. In absolute terms, E&U's 16 YES cases are double F&B's 8 YES cases, suggesting broader institutionalization of modeling practices in the energy domain. NO rates are inversely aligned with adoption: F&B shows the highest NO at 38.46% (5 of 13), PA follows with 36.83% (7 of 19), and E&U has the lowest NO at 30.44% (7 of 23). PA and F&B differ by only 1.63 pp (63.17% vs 61.54%), hinting that service-oriented sectors may be converging on a similar adoption profile. Aggregating across sectors

Table 3: Holistic EA approach per industry sector – Cluster A: Usage of ArchiMate per Industry sector

Industry Sector	YES	NO	Total	YES%	NO%
PA	12	7	19	63.17	36.83
F&B	8	5	13	61.54	38.46
E&U	16	7	23	69.56	30.44

yields an overall YES total of 36 of 55 (65.45%), a consolidated measure not shown in the table but indicative of two−thirds adoption overall. The range of YES% (from 61.54% to 69.56%) is 8.02 pp, which supports an interpretation of moderate dispersion rather than sharp divergence. Viewed through relative intensity, E&U's advantage is more pronounced against F&B in both absolute (+8 cases) and proportional (+8.02 pp) terms than it is against PA. Taken together, these results indicate a mature baseline of ArchiMate usage across sectors, with E&U securing the leading position, PA holding a strong intermediate stance, and F&B trailing slightly but within a narrow margin.

Future-oriented EA adoption mirrors the current pattern: E&U holds 16 of 23 (69.56%), PA remains at 12 of 19 (63.17%), and F&B stays at 8 of 13 (61.54%). The exact replication of percentages across sectors indicates no reordering of relative positions between present usage and intended future adoption. Aggregating TO-BE across sectors yields 36 of 55 YES (65.45%), identical to the AS-IS aggregate, signifying steady-state intent rather than planned contraction or expansion at the macro level. The TO-BE NO total remains 19 of 55 (34.55%), with F&B continuing to show the highest NO proportion at 38.46%. Inter-sector gaps are unchanged (E&U vs PA: 6.39 pp; E&U vs F&B: 8.02 pp; PA vs F&B: 1.63 pp), which suggests convergent expectations across sectors. E&U's future commitment of 16 cases exceeds PA by 4 cases and F&B by 8 cases, reinforcing its leadership posture. PA's identical counts (12 YES, 7 NO) across current and future states reflect governance continuity rather than acceleration or retreat. The cross-sector mean TO-BE YES% remains approximately 64.76%, reinforcing the generalization that around two-thirds of respondents plan to use ArchiMate. The narrow dispersion (a range of 8.02 pp) implies coordinated sectoral trajectories, with variation bounded by sector-specific constraints rather than divergent strategic orientations.

Based on the reported counts and percentages, the interpretation aligns with the updated data. Public Administration (PA) exhibits perfect continuity between AS-IS and TO-BE states, maintaining 12 YES (63.17%) and 7 NO (36.83%) in both, signaling steady-state governance rather than planned expansion. Finance/Banking/Insurance (F&B) demonstrates the largest positive shift, rising from AS-IS YES = 5 (38.46%) to TO-BE YES = 8 (61.54%), a net gain of 3 cases and +23.08 percentage points. Energy/Utility (E&U) also advances, increasing YES from 13 (56.52%) to 16 (69.56%), a gain of 3 cases and +13.04 percentage points, while NO falls from 10 (43.48%) to 7 (30.44%). Aggregating across sectors, AS-IS YES totals 30 of 55 (54.55%), and TO-BE YES totals 36 of 55 (65.45%), producing an overall increase of +6 cases and +10.91 percentage points toward future usage. For E&U, the uplift narrows and then reverses the relative gap to PA: from trailing by 6.65 pp (56.52% vs 63.17%) in AS-IS to leading by 6.39 pp (69.56% vs 63.17%) in TO-BE. The TO-BE dispersion (61.54%–69.56%) remains 8.02 pp, implying aligned trajectories despite differing baselines and sectoral constraints. Overall, F&B undertakes the most ambitious step-change, E&U consolidates its lead, and PA opts for stability, together indicating stronger forward alignment around ArchiMate language across sectors.

The Schema **1** shows two heat maps comparing current (AS-IS) and future (TO-BE) states of ArchiMate adoption across three regulated sectors: PA (Public Administration), F&B (Finance/Banking/Insurance), and E&U (Energy/Utility). The left panel represents the

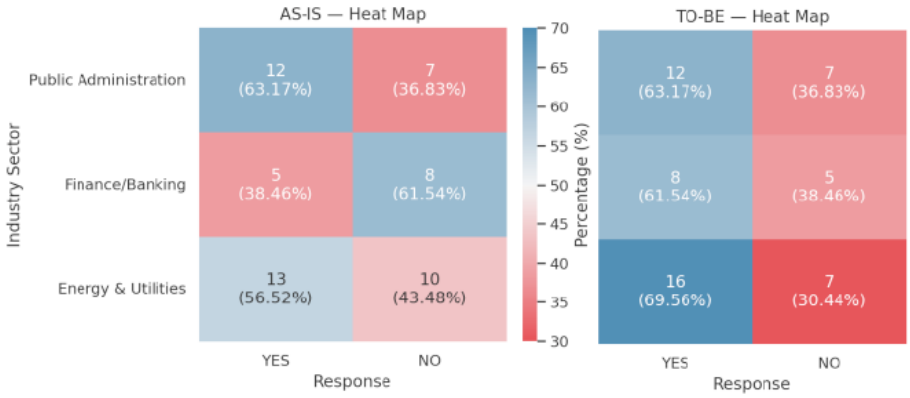
Table 4: Holistic EA Approach Per Industry Sector – Cluster B: TO-BE (future state) for EA Per Industry Sector

Industry Sector	YES	NO	Total	YES%	NO%
PA	12	7	19	63.17	36.83
F&B	8	5	13	61.54	38.46
E&U	16	7	23	69.56	30.44

Table 5: Holistic EA Approach Per Industry Sector – Cluster C: ArchiMate Language for AS-IS (current state) & TO-BE (future state) for EA Per Industry Sector

Industry Sector	AS-IS		TO-BE		AS-IS		TO-BE	
	YES	NO	YES	NO	YES	NO	YES	NO
PA	12	7	12	7	63,17	36,83	63,17	36,83
F&B	5	8	8	5	38,46	61,54	61,54	38,46
E&U	13	10	16	7	56,52	43,48	69,56	30,44

Legend: PA – Public Administration; F&B – Finance/Banking/Insurance; E&U – Energy/Utility.



Schema 1: Heat map coverage by states and sector (quantitative).

existing situation, while the right panel illustrates anticipated changes. Color intensity reflects adoption levels, highlighting sectoral differences and trends. PA remains stable, F&B demonstrates the most significant forward shift, and E&U strengthens its leading position. Overall, the comparison indicates a clear alignment toward broader ArchiMate usage in future enterprise architecture initiatives.

B. Qualitative Semi-Structured Interviews Results

1) Overview of Cross-Sector Coverage

Across all nine focus areas, E&U exhibits the broadest thematic coverage (48 KI mentions), slightly exceeding PA (47) and F&B (44), indicating a relatively balanced yet sector-differentiated landscape. When normalized by focus areas (nine domains), this equates to an average of 5.33 KIs per focus area for E&U, 5.22 for PA, and 4.89 for F&B, indicating E&U's broader thematic engagement with EA-related concerns. The shared cores—KIs that appear in all three sectors within a given focus area—are strongest in EA and BA (three KIs each), moderate in PjM, BUS & ICT, and StM (three KIs each), and minimal in IF and ArchiMate (one KI each), evidencing varying degrees of cross-sector consensus. These patterns already point to common alignment themes (KI4, KI5, KI6) recurring across strategic and architectural domains, with greater sectoral divergence in operational interfaces (IF) and modeling tool usage (ArchiMate).

2) Enterprise Architecture (EA)

In EA, shared insights are KI4 (alignment), KI5 (governance), and KI6 (decision rights), which are present across all sectors, forming a three-item core that signals a convergent emphasis on structured coordination. PA lists six KIs (KI1, KI2, KI4, KI5, KI6, KI8) and F&B lists five (KI1, KI2, KI4, KI5, KI6), both foregrounding early-phase concerns (KI1–KI2), which together account for two of six elements in PA (≈ 33%) and two of five in F&B (≈ 40%). By contrast, E&U lists six KIs (KI3, KI4, KI5, KI6, KI7, KI9) and uniquely adds advanced/structural issues—interfaces (KI3), change (KI7), and boundaries (KI9), which collectively constitute three of six (≈ 50%) of its EA profile. This distribution indicates that PA/F&B skew toward initiation and scoping, while E&U skews toward integration and transformation mechanics, a difference that is qualitative (content types) as much as it is quantitative (counts).

3) Business Architecture (BA)

BA shows a stable, shared foundation in KI4–KI6, present across all sectors, reinforcing consistency in structural principles (alignment, governance, decision rights). PA covers six KIs (KI1, KI2, KI4, KI5, KI6, KI8) and broadens scope with culture/capabilities (KI8) and initiation (KI1–KI2); F&B covers four KIs (KI2, KI4, KI5, KI6) focusing on clarity and governance; E&U spans five KIs (KI4, KI5, KI6, KI8, KI10) and uniquely adds

portfolio/program linkages (KI10). The presence of KI10 only in E&U suggests a forward-looking orientation toward benefits and prioritization governance, while PA's inclusion of KI8 signals organizational culture and capability concerns that are comparatively less visible in F&B. In proportional terms, PA's non-shared additions (KI1, KI2, KI8) constitute 50% of its BA set, F&B's additional KI2 accounts for 25%, and E&U's additions (KI8, KI10) represent 40%, demonstrating distinct expansion vectors from the shared core.

4) Governance of Change: Program & Project (Pj&PgM)

PgM converges on KI5 and KI10 across sectors (a two-item shared core), while PA includes KI2 and KI3, F&B includes KI2 and KI4, and E&U includes KI3, KI4, and KI9. The breadth totals are PA = 5, F&B = 4, E&U = 5, with E&U uniquely adding KI9 (boundaries/roles)—a signal of coordination demands in complex portfolios. PjM exhibits a stronger shared core (KI4, KI5, KI10; three items) and equal breadth (five KIs in each sector), whereas PA adds KI2 and KI9 (initiation, oversight), while F&B adds KI1 (authority), and E&U reiterates KI4–KI6 (coordination/control). Together, PgM/PjM results suggest cross-sector agreement on governance/control (KI5, KI10), with PA gravitating toward initiation and oversight, F&B toward authority and clarity, and E&U toward coordination and boundary management.

5) BUS & ICT Integration

BUS & ICT exhibits the widest cross-sector coverage overall, with PA listing eight KIs, E&U seven, and F&B six, and a shared core of KI4 (alignment), KI5 (governance), KI7 (change). PA's eight-item profile includes culture/capabilities (KI8) and decision rights (KI6), underscoring organizational alignment as much as technical fit. E&U adds KI3 and KI10, connecting interfaces/dependencies with portfolio linkages, which together represent 2 of 7 (≈ 29%) of its BUS & ICT set. F&B's six KIs emphasize clarity and governance, omitting interfaces (KI3) and portfolio linkages (KI10), which indicates a leaner, control-centric profile. The counts and composition suggest that PA prioritizes socio-organizational alignment, E&U bridges technical integration with strategic portfolio oversight, and F&B maintains disciplined governance without extending to interface-portfolio complexities.

6) Information Flow (IF)

IF has the smallest shared core (only KI5 across all sectors), revealing sectoral divergence in how information flow challenges are framed. PA lists four KIs (KI1, KI2, KI5, KI8) emphasizing initiation/clarity (KI1–KI2) and culture/capabilities (KI8); F&B lists six KIs (KI2, KI4, KI5, KI7, KI8, KI9) centering on governance (KI4, KI9) and change (KI7); E&U lists six KIs (KI1, KI3, KI4, KI5, KI6, KI7) highlighting interfaces (KI3) and decision rights (KI6). In proportional terms, PA's clarity/culture pair (KI2, KI8) constitutes 50% of its IF profile, F&B's governance pair (KI4, KI9) constitutes 33%, and E&U's interface/decision pair (KI3, KI6) constitutes 33%, underscoring distinct operational inhibitors. These distributions indicate that information flow issues are perceived as communication/culture in PA, governance boundaries in F&B, and technical/organizational interfaces in E&U.

7) Stakeholder Management (StM)

StM shows a three-item shared core (KI4, KI5, KI10) across all sectors, reflecting alignment, governance, and program linkages as common engagement goals. PA and E&U each list seven KIs, while F&B lists six, with PA/E&U adding KI6 and KI8 (decision rights, culture/capabilities) and F&B adding KI9 (boundaries/roles). The presence of KI6 and KI8 in PA/E&U (constituting 2 of 7 ≈ 29% each) indicates greater emphasis on authority and cultural readiness, whereas F&B's inclusion of KI9 (≈ 17% of its StM set) suggests sharper delineation of stakeholder roles. This pattern aligns with observed governance differences: PA/E&U tend to formalize decision-making structures, while F&B tends to clarify boundaries, each achieving stakeholder engagement through different institutional levers.

8) ArchiMate usage and Role

In ArchiMate, the shared core reduces to a single insight (KI4), confirming the tool's function as a boundary object for communication and alignment across sectors. PA lists two KIs (KI4, KI5), F&B lists four (KI3, KI4, KI5, KI6), and E&U lists three (KI1, KI4, KI6), evidencing varied breadth of usage. F&B's four-item set (including interfaces (KI3) and decision rights (KI6)) implies a broader modeling remit, while E&U's inclusion of initiation (KI1) points to visualization supporting change narratives from early stages. Proportionally, KI4 constitutes 50% of PA's ArchiMate profile, 25% of F&B's, and 33% of E&U's, reinforcing that communication/alignment is central but not exclusive to tool usage. These counts indicate that sectors utilize ArchiMate differently—as a communication anchor in PA, a multi-purpose modeling scaffold in F&B, and a visual change companion in E&U.

9) Digital Transformation (DT)

DT goals converge on KI5 and KI7 across sectors (a two-item shared core), highlighting alignment/governance and change management as the dual pillars of transformation. All sectors list four KIs,

but PA adds KI10 (portfolio linkages), F&B adds KI2 (initiation), and E&U adds KI3–KI4 (interfaces, alignment), indicating distinct emphases within an otherwise balanced breadth. In compositional terms, PA's governance linkage (KI10) accounts for 25% of its DT profile, F&B's initiation (KI2) accounts for 25%, and E&U's interface/alignment pair (KI3–KI4) accounts for 50%, underscoring sector‑tailored transformation pathways. These differences suggest that PA prioritizes portfolio governance, F&B underscores starting conditions and scoping clarity, and E&U foregrounds integration and alignment mechanics during change.

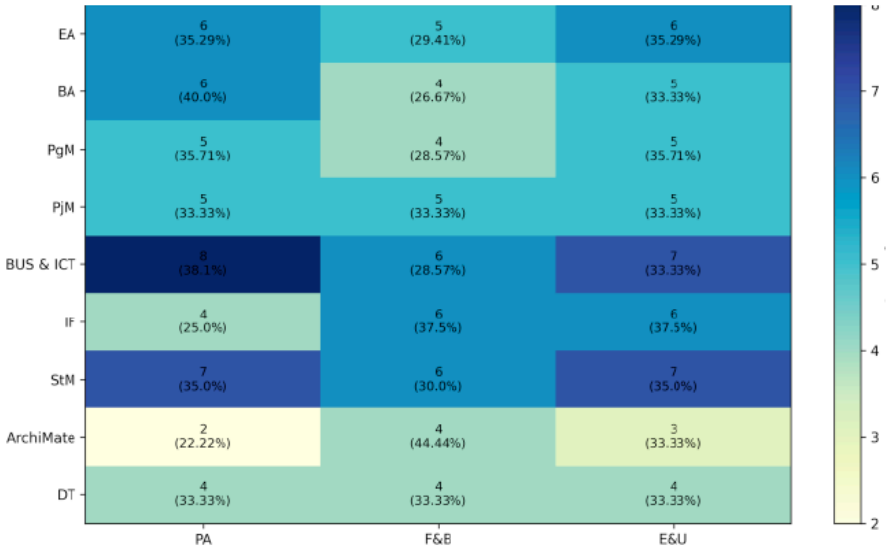
10) Cross-Cutting Synthesis and Implications

Taken together, the shared cores (EA/BA: three KIs; PjM/BUS & ICT/StM: three KIs; PgM/DT: two KIs; IF/ArchiMate: one KI) demonstrate robust cross-sector consensus around alignment (KI4), governance (KI5), decision rights (KI6), and change (KI7), while interfaces (KI3), culture/capabilities (KI8), boundaries (KI9), and portfolio linkages (KI10) differentiate sectors. E&U's highest overall coverage (48) reflects strong integration and coordination needs, PA's near‑parity (47) indicates broad governance and cultural alignment concerns, and F&B's focused coverage (44) highlights clarity and authority themes. The balance of shared vs. sector-specific KIs suggests that common EA principles are widely recognized, but implementation priorities diverge by institutional context: PA and F&B gravitate to initiation/clarity, whereas E&U emphasizes integration/change and boundary management. For practice, this implies that cross-sector EA frameworks should retain a stable core (alignment, governance, decision rights) while allowing configurable extensions in interfaces, culture, boundaries, and portfolio linkages. For research, the differentiated KI compositions provide a testable basis for exploring maturity trajectories, governance mechanisms, and tool-mediated communication across public, financial, and energy domains.

Broadest coverage: BUS & ICT is the highest across sectors, with PA = 8, E&U = 7, F&B = 6, indicating pervasive alignment/governance and integration concerns in this domain. Strong governance cores: EA, BA, PgM, and PjM exhibit relatively balanced counts (EA: PA=6, F&B=5, E&U=6; BA: 6/4/5; PgM: 5/4/5; PjM: 5/5/5), which reflects shared attention to alignment (KI4), governance (KI5), and decision rights (KI6). Information Flow (IF): Diverges by sector with PA = 4 vs F&B = 6 and E&U = 6, suggesting PA's narrower focus (clarity/culture) compared to the broader governance/interfaces emphasis in F&B and E&U. Stakeholder Management (StM): Shows high engagement (PA = 7, E&U = 7, F&B = 6) consistent with decision rights and cultural capability themes. ArchiMate: Breadth varies, with F&B = 4 (the broadest tool use), E&U = 3, and PA = 2, aligning with sectoral differences in modeling scope and visualization needs. DT: Balanced across sectors (4/4/4), reflecting a shared foundation in alignment/governance and change management, with sector-specific add-ons (*e.g.*, portfolio linkages in PA, initiation in F&B, interfaces/alignment in E&U) captured in your table.

11) Energy Sector-Specific Insights: Smart Grids, DERs, Governance, Sustainability, and Business–IT/OT Alignment

The Energy & Utilities (E&U) sector demonstrates the highest level of Enterprise Architecture (EA) and ArchiMate adoption (69.56%), surpassing public administration and finance. This leadership reflects the sector's structural complexity and regulatory intensity,



Schema 2: Heat map coverage by focus area and sector (qualitative).

where EA serves as a strategic enabler for smart grid orchestration, energy data platform interoperability, and distributed energy resource (DER) integration. EA artifacts and ArchiMate viewpoints model interfaces between grid assets, IoT sensors, SCADA systems, and market platforms, ensuring traceability and cybersecurity compliance in sensitive operational contexts. This IT/OT integration underpins predictive maintenance and real-time grid monitoring, improving operational reliability and data quality across the energy value chain.

Qualitative evidence indicates that E&U prioritizes interface modeling and boundary management (KI3, KI9) alongside decision rights (KI6), with TOGAF ADM phases providing the governance cadence to align regulatory compliance with operational decisions and to maintain transparent portfolio governance under cybersecurity and reliability constraints. EA adoption patterns in E&U correlate with sustainability objectives. TO-BE modeling facilitates the integration of renewable energy sources and supports the 3Ds—Decarbonization, Decentralization, and Digitalization—while EA viewpoints enable scenario planning for carbon-neutral strategies that are consistent with national regulations. Survey results confirm that an emphasis on TO-BE modeling anchors large-scale digital transformation by aligning business objectives with IT architectures. EA artifacts serve as boundary objects that facilitate seamless communication between strategic planners and technical teams, thereby accelerating digital maturity, strengthening business-IT alignment, and enhancing long-term system efficiency and resilience.

5. DISCUSSION

Interpretation of the results for answering RQ#1 - Across the three regulated domains, the study evidences a mature and convergent baseline of ArchiMate usage with E&U leading, PA stable, and F&B showing the strongest forward intent through a marked shift from AS-IS to TO-BE modelling. This pattern is consistent with the demands of regulated, asset-intensive, or service-oriented environments, where stakeholder-oriented architecture descriptions and traceable decisions are essential to reconcile organizational goals with operational realities across business, application, data, technology, and infrastructure layers [36]. The survey confirms that E&U leads in EA and ArchiMate adoption, with 69.56% usage for both AS-IS and TO-BE modelling, surpassing PA (63.17%) and F&B (61.54%). This leadership reflects the sector's structural complexity and regulatory intensity, where EA serves as a strategic integrator for IT convergence, grid modernization, and cybersecurity compliance. Unlike PA's governance stability and F&B's forward intent, E&U demonstrates continuous alignment between operational and architectural layers, positioning EA as a driver of digital maturity rather than a mere documentation tool [1, 6]. The qualitative interviews reinforce this picture by surfacing a shared governance core—alignment (KI4), governance (KI5), decision rights (KI6), and change (KI7)—while sectoral differentiation emerges around interfaces (KI3), culture/capabilities (KI8), boundaries/roles (KI9), and portfolio linkages (KI10). Taken together, the quantitative and qualitative strands support the view that EA serves as a socio-technical coordination mechanism for DT, enabling the negotiation of AS-IS constraints and TO-BE design among diverse stakeholders and their integration into portfolio decisions [1, 6]. In this sense, the study confirms EA's dual function: operationalising stakeholder management and serving as a documentation and communication mechanism for the current and target states.

Interpretation of the results for answering RQ#2 and RQ#3 - Methodologically and practically, TOGAF ADM provides configurable, iterative guidance for architecture development and governance in DT programmes, while ArchiMate 3.2 offers a layered metamodel and viewpoint mechanism that maps naturally to AS-IS/TO-BE transitions and stakeholder-specific visualisation [37]. In organisational communication terms, visual artefacts such as ArchiMate operate as boundary objects—robust enough to maintain structural coherence and plastic enough to support multiple interpretations—thus bridging heterogeneous communities (business, IT, compliance, operations) without requiring full semantic consensus [3, 35].

Despite high adoption, E&U faces persistent inhibitors: communication gaps between IT and other teams, limited decision-making authority for EA practitioners, and organisational silos that slow portfolio integration. These inhibitors mirror patterns in PA and F&B but are amplified in E&U due to asset intensity and regulatory obligations. Interviews highlight that boundary management (KI9) and interfaces (KI3) are recurring pain points, requiring governance models that internalise external constraints (cybersecurity, interoperability, market design) into EA principles [3, 37]. Interview evidence reveals sector-specific boundary object patterns: PA treats ArchiMate primarily as a communication anchor, F&B uses it as a multi-purpose modelling scaffold, and E&U attaches it to change narratives already in early phases (Pj&PgM). These configurations align with the governance core while pragmatically adapting to domain-specific realities [3, 37].

Interpretation of the results for answering RQ#3 - The leading position in ArchiMate adoption and emphasis on TO-BE reflects the need to orchestrate business-IT integration, manage interfaces across assets and systems, and handle boundary and change issues in portfolio Pj&PgM governance. This is consistent with the literature on smart grid modernization, decentralization, and the integration of IoT/AI, where interoperability, cybersecurity, and reliability constraints must be internalized through EA governance [22, 32]. The sector's interface-heavy and coordination-intensive profile underscores the value of EA artefacts and viewpoints for transparent and traceable decision-making under regulatory obligations [1, 37]. The study demonstrates that ArchiMate serves as a boundary object in E&U, facilitating syntactic, semantic, and pragmatic bridging across heterogeneous communities. Unlike PA, which uses ArchiMate mainly for communication, and F&B, which applies it for governance clarity, E&U leverages ArchiMate for visualising change narratives early in DT programmes, supporting impact analysis and migration sequencing [1, 3]. EA tools in E&U further enhance scenario modelling, heatmaps, and role-based access, which are essential for portfolio-level prioritisation and risk evaluation in regulated environments [25]. This confirms that tool maturity directly correlates with strategic alignment and TO-BE modelling effectiveness, making EA tooling a critical enabler of DT success metrics such as interoperability and reliability [22, 31].

A. Enterprise Architecture as an Enabler for Smart Grid, DER, Governance, Sustainability, Integration and Business-IT Alignment, and Cybersecurity

EA's layered architecture and ArchiMate viewpoints provide a strategic blueprint for integrating smart grid components, energy data platforms, and DERs. By modeling dependencies across business, application, and technology layers, EA supports interoperability and ensures compliance with cybersecurity requirements—key prerequisites for digital energy ecosystems. The adoption of TOGAF ADM phases enables iterative governance, risk evaluation, and secure configuration, while EA tools enhance scenario modeling and role-based access management to protect energy infrastructures against cyber threats. These capabilities are vital for maintaining operational continuity in highly regulated environments. From a practical perspective, future EA frameworks for energy utilities should incorporate cybersecurity standards such as ISO/IEC 27001 and energy-specific interoperability protocols to strengthen resilience and sustainability. This integration not only accelerates digital transformation but also aligns business objectives with IT and OT systems, ensuring coherent execution of modernization initiatives across portfolios.

B. Sustainability and Resilience through Enterprise Architecture

EA advances sustainability in energy utilities by embedding governance and integrated planning into DT initiatives, which are delivered by Pj&PgM. TOGAF ADM and ArchiMate modeling provide a holistic view of business, application, and technology layers, ensuring modernization efforts—such as smart grids and distributed energy resource integration—align with long-term efficiency goals. EA supports resilience against disruptions and regulatory risks by modeling dependencies and migration paths, while enabling IT/OT interoperability for adaptability and secure operations. Rather than introducing new metrics, EA strengthens governance frameworks to embed sustainability principles into architectural decisions, driving carbon reduction, resource optimization, and enduring system reliability.

C. Governance, Compliance, and Interoperability Implications of EA Adoption

EA adoption in energy utilities strengthens governance by embedding structured decision-making and accountability into DT initiatives. TOGAF ADM phases provide a governance cadence that ensures architectural principles and migration strategies align with regulatory obligations, reducing compliance risks in highly regulated environments. EA artifacts and ArchiMate viewpoints enable transparent modeling of dependencies across business, application, and technology layers, which is critical for demonstrating adherence to cybersecurity and reliability standards. Furthermore, EA facilitates IT/OT interoperability, allowing seamless integration of smart grid components, energy data platforms, and distributed energy resources. This interoperability not only enhances system reliability and resilience but also supports real-time monitoring and predictive maintenance, ensuring that modernization initiatives deliver sustainable and secure energy infrastructures.

6. CONCLUSION

This study establishes EA as a strategic enabler of DT and DM in the Czech energy sector, outperforming PA and F&B in both adoption and depth of integration. E&U's leadership in ArchiMate utilisation and TO-BE modelling underscores EA's role as a socio-technical coordination mechanism that aligns business and IT [1, 3, 35, 38, 39], embeds regulatory compliance into transformation governance. The study also contributes by: (i) empirically demonstrating sector-specific adoption patterns and inhibitors in regulated environments; (ii) theoretically reinforcing EA's dual function as governance and communication

infrastructure; and (iii) practically proposing a configurable governance framework and EA–Pj&PgM coupling for portfolio-level DT management.

In summary, EA—supported by standards, modeling languages, and boundary-object practices—offers a reusable platform for the coherent execution of DT initiatives in energy and other regulated sectors [5, 6].

LIMITATIONS OF THE RESEARCH

Despite its scope, three limitations of a study are seen: 1) the respondents are only from the Czech Republic, the case study covers specifics of the Czech Republic (not covering international conditions), 2) the graphical notation language ArchiMate for EA modelling is a de facto standard in the Czech Republic at the national level [40] and 3) non-probability (convenience) sampling via professional networks may introduce self-selection bias and limit generalizability. The survey response count constrains statistical inference; the interview component involves a small number of participants (one per industry), which limits its breadth. Findings rely on self-reported adoption and usage, which may be affected by recall or social desirability bias.

CALL FOR FURTHER RESEARCH

Future research should quantify the causal links between EA maturity and DT success metrics (*e.g.*, interoperability, cybersecurity, reliability), and extend the comparative analysis beyond the Czech Republic to include cross-country regulatory diversity [31, 32, 36].

PRACTICAL IMPLICATIONS FOR ENERGY UTILITIES

EA provides energy utilities with a structured foundation for managing the complexity of smart and sustainable energy systems. By leveraging TOGAF ADM and ArchiMate viewpoints, utilities can align strategic objectives with operational execution, ensuring compliance with stringent regulatory frameworks while accelerating modernization initiatives such as smart grid deployment and DER integration. EA-driven DT supports IT/OT convergence, enhances

Table 7: Summary of Answers from Semi-Structured Narrative Interview with Key Non-EA & Non-IT Key Stakeholders

Focus Area	PA — Extract key insights	F&B — Extract key insights	E&U — Extract key insights	Similarities & differences	Conclusions
EA	KI1, KI2, KI4, KI5, KI6, KI8	KI1, KI2, KI4, KI5, KI6	KI3, KI4, KI5, KI6, KI7, KI9	Common: KI4, KI5, KI6; Differences: PA & F&B emphasize early insights (KI1, KI2); E&U stresses advanced issues (KI7, KI9)	Core EA concerns shared; sectoral priorities diverge—PA & F&B stress initiation, E&U emphasizes boundaries and change
BA	KI1, KI2, KI4, KI5, KI6, KI8	KI2, KI4, KI5, KI6	KI4, KI5, KI6, KI8, KI10	Common: KI4, KI5, KI6; Differences: PA adds KI1, KI2, KI8; E&U adds KI10	Foundational BA principles consistent; PA broader scope, E&U forward-looking
PgM	KI2, KI3, KI5, KI9, KI10	KI2, KI4, KI5, KI10	KI3, KI4, KI5, KI9, KI10	Common: KI5 & KI10; Differences: PA includes KI2; F&B lacks KI9	Program governance shared; PA stresses initiation, E&U emphasizes coordination
PjM	KI2, KI3, KI4, KI9, KI10	KI1, KI3, KI5, KI6, KI10	KI3, KI4, KI5, KI6, KI10	Common: KI4, KI5, KI10; Differences: PA includes KI2 & KI9; F&B includes KI1	Project practices converge; PA highlights initiation, F&B emphasizes authority
BUS & ICT	KI1, KI2, KI4, KI5, KI6, KI7, KI8, KI9	KI2, KI4, KI5, KI6, KI7, KI9	KI1, KI3, KI4, KI5, KI7, KI9, KI10	Common: KI4, KI5, KI7; Differences: PA comprehensive; E&U adds KI3, KI10	Alignment challenges pervasive; PA spans culture, E&U adds change, F&B focuses on clarity
IF	KI1, KI2, KI5, KI8	KI2, KI4, KI5, KI7, KI8, KI9	KI1, KI3, KI4, KI5, KI6, KI7	Common: KI5; Differences: PA stresses KI2 & KI8; F&B includes KI4, KI7, KI9	Information flow shared inhibitor; PA emphasizes clarity, F&B governance, E&U interfaces
StM	KI1, KI4, KI5, KI6, KI7, KI8, KI10	KI1, KI4, KI5, KI7, KI9, KI10	KI1, KI3, KI5, KI6, KI7, KI8, KI10	Common: KI4, KI5, KI10; Differences: PA & E&U include KI6 & KI8; F&B includes KI9	Shared goals on engagement; PA & E&U emphasize decision rights, F&B stresses boundaries
ArchiMate	KI4, KI5	KI3, KI4, KI5, KI6	KI1, KI4, KI6	Common: KI4; Differences: F&B broader use; E&U emphasizes visualization	ArchiMate as boundary object for communication and alignment
DT	KI4, KI5, KI7, KI10	KI2, KI5, KI7, KI10	KI3, KI4, KI5, KI7	Common: KI5, KI7; Differences: PA includes KI10; F&B includes KI2	DT goals converge on alignment; PA stresses governance, F&B initiation, E&U change

Legend: PA – Public Administration; F&B – Finance & Banking; E&U – Energy & Utilities. Key insights: KI1 - Firefighting culture; KI2 - Insufficient information flow; KI3 - Frequent changes; KI4 - Communication problems/misunderstandings; KI5 - No Business & IT alignment; KI6 - Lack of decision power; KI7 - Decentralized Business and centralized IT; KI8 - Lack of insufficient top management support; KI9 - Organizational boundaries; KI10 - Weak Pj&PgM approach.

interoperability across energy data platforms, and embeds cybersecurity safeguards into architectural decisions—critical for operational resilience and reliability. Equally important, EA strengthens stakeholder management by offering boundary objects and governance mechanisms that facilitate transparent communication among regulators, technical teams, and business leaders. This engagement ensures decision rights, accountability, and cultural readiness are embedded into transformation programs, reducing resistance and improving adoption. Practically, utilities should adopt configurable EA frameworks integrated with Pj&PgM practices to harmonize governance, stakeholder engagement, and sustainability objectives. This approach enables predictive maintenance, real-time grid monitoring, and scenario planning for renewable integration, driving long-term efficiency, resilience, and alignment with decarbonization and resource optimization goals.

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