EDITORIAL

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The importance of systematical analysis and evaluation methods for energy business ecosystems

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In recent years, business ecosystems have gained popularity in many sectors due to the increasing awareness of the value of being part of an ecosystem or creating their own ecosystems. This trend is observed for leading Tech companies, such as Apple, Google, Microsoft, and Alibaba, who have become platform ecosystem leaders.

However, business ecosystems in energy are relatively less researched than other sectors, and many studies in the energy sector are still at the device or the system levels. A business ecosystem modelling framework is proposed by (Ma 2019) and applied in the energy sector with examples in (Ma et al. 2017, 2019).

Although a business ecosystem architecture development methodology is proposed being part of the business ecosystem modelling framework (Ma et al. 2021), how to systematically analyze energy ecosystems and efficiently identify opportunities and solutions that can benefit the ecosystem and its stakeholders remain unclear.

The missing literature in business ecosystems research

The studies on the impact factors in business and strategies can be tracked from ETPS (Economic, technical, political, and social) (Aguilar 1967), STEP (Social, technical, economic, political) (Brown and Weiner 1984), and STEPE (Social, technical, economic, political, and ecological) (Davenport and Prusak 1997). Later on, many related acronyms are proposed whereas PEST becomes the most popular one. However, the main focus of these impact factors is individual and organizational strategies, and the business ecosystem perspective is not considered.

In the theory of business ecosystem, Moore (1993) states co-evolution in his definition of the business ecosystem as "organizations and individuals… coevolve their capabilities and roles and tend to align themselves in the ecosystem ". Later on, value co-creation and co-evolution become one of the primary research focuses, e.g., (Peltoniemi et al. 2004; Tanev et al. 2010). However, the indicators and assessment of ecosystem conditions have not been addressed systematically as in the ecological ecosystem domain. In the ecological ecosystem field, assessment and indicators of ecosystem conditions (European Union 2013) (Maes et al. 2018) and ecosystem change (Elmqvist et al. 2003)

have been popularly discussed. Based on the experience from the ecological ecosystem domain, the indicators and assessment of business ecosystem conditions are essential for understanding current ecosystem conditions, future ecosystem trends, and differences across business ecosystems.

From the system engineering perspective, system dynamics are used to identify attractors and properties of a system (Bousquet and Le Page 2004), represent, explore and simulate the complex feedback and interactions among system elements (Elsawah et al. 2017). However, the evolution/co-evolution perspective is rarely discussed although there are discussions in, e.g., system thinking (Rubenstein-Montano et al. 2001), machine logic (Polic and Jezernik 2005), or risk management/ assessment (Sage and Rouse, 2014).

CSTEP: five critical business ecosystems dimensions

Therefore, to fill the gap, five critical business ecosystems dimensions called CSTEP are proposed for systematically understanding a targeted business ecosystem:

Climate, environment, and geographic situation.

Societal culture and demographic environment.

Technology (Infrastructure, technological skills, technology readiness).

Economy and finance.

Policies and regulation.

The CSTEP covers five influential dimensions that impact a specific business environment, and it is difficult to have universal definitions that apply to every business ecosystem. A general definition of CSTEP dimensions and sub-dimensions can be described as shown in Table 1. The explanation is based on the definitions from the Cambridge Dictionary and other authorities, such as NASA and United Nations.

Meanwhile, the five CSTEP dimensions can be divided into macro and micro levels based on the focuses (general or specific) of the business ecosystems. The main difference between these two is either from the ecosystem perspective or from the individual stakeholder perspective. For instance, for microgrid design, it is necessary to investigate the macro level of the C-dimension. Comparatively, for smart building development, the micro-level of the C-dimension is more important. Table 2 summarizes the general matters for each CSTEP dimension at both macro and micro levels in the energy domain.

The proposal of a novel CSTEP ecosystem analysis and evaluation method

The CSTEP has been applied in energy ecosystems with various cases, e.g., microgrid design (Ma et al. 2018) and evaluation of dynamic distribution tariffs (Christensen et al. 2021). These applications show that the CSTEP can be used to analyze energy ecosystems, identify opportunities & solutions and their impacts.

However, a methodology is needed to clearly introduce and elaborate the process to apply CSTEP for analyzing and evaluating business ecosystems. Based on previous studies, the methodology should cover three aims:

- ***Business opportunity identification.*** By investigating unmet needs and megatrends in a given business ecosystem, the future/ideal ecosystems can be portrayed, and the correlated business opportunities can be identified.

Table 1 Definitions of CSTEP five dimensions

Dimension	Sub-dimension	Explanation
Climate, environmental and geographic situation	Climate	The general weather (including seasons) conditions that are usually found in a particular place
	Environment	The conditions that people live, work or spend time in and the way that they influence how they feel, behave or work
	Geographic situation	The natural features of a place, such as mountains and rivers
Societal culture, demographic environment	Societal culture	The way of life or work, especially the general customs and beliefs, of a society or an organization
	Demographic environment	The demography of an area is the number and characteristics of the people who live in an area, in relation to their age, sex, if they are married or not, etc
Technology readiness	Infrastructure	The basic systems and services, such as transport and power supplies, that a place uses in order to work effectively
	Technology development capacity	The set of capacities to plan for technology transfer and development to achieve regional and national goals (United Nations Department of Economic and Social Affairs 2013)
	Technology maturity	Refer to the Technology Readiness Levels (TRL) for assessing the maturity level of a particular technology (NASA 2021)
	Technological skills	The knowledge and expertise needed to accomplish complex actions, tasks and processes relating to computational and physical technology
Economy and finance	Economy	Economy related to market trade, industry
	Finance	Cost of labour, material, maintenance, and service Revenue from sales, income, compensation, Return-on-Investment
Policies and regulation	Policy	the activities of the government, members of law-making organizations, or people who try to influence the way a country is governed
	Regulation	An official rule or the act of controlling something

- ***Technology feasibility evaluation.*** With defined CSTEP multi-dimensional criteria, selected technologies are evaluated based on their impacts on the business ecosystem. Therefore, technologies that can benefit the business ecosystem and its stakeholders the most will be adopted.

Table 2 Macro and micro levels of the five CSTEP dimensions

Dimension	Macro-level	Micro-level
Climate, environmental and geographic situation	Climate and geographic situation: the general weather conditions and the natural features of a place, e.g •Nature resources (e.g., wind, solar, natural gas) •Natural disasters (e.g., earthquake, tsunami) •Climate zone	Environment: the living, working or production environment or conditions e.g., •Temperature •Humidity •Lighting •CO_2, •Noise, TVOC, PM2.5, etc •Pollution
Societal culture, demographic environment	Demographic environment: the demography of an area is the number and characteristics of the people who live in an area, in relation to their age, sex, if they are married or not, etc. E.g., •Population •Gender equality •Public safety •Societal stability •Corruption •Cultural dimension •Social relations •Education	Societal culture: organizational/market/sectoral interests, concerns, beliefs, e.g., •Convenience •Uncertain avoidance •Cost–benefit acceptance •Social/ environmental welfare, security (e.g., environment concern)
Technology (Infrastructure, facilities, technological skills, technology readiness)	•Infrastructure: the basic systems and services, such as transport and power supplies, that a place uses to work effectively •Technology development capacity: The set of capacities to plan for technology transfer and development to achieve regional and national goals (United Nations Department of Economic and Social Affairs 2013)	•Technology Readiness Levels (TRL) for assessing the maturity level of a particular technology (NASA 2021) •Technological skills: the knowledge and expertise needed to accomplish complex actions, tasks and processes relating to computational and physical technology
Economy and finance	Economy relates to market, trade, industry, e.g •Employment rate •Living costs •Investments •Growth rate •Financial stability •Inflation rate	Finance relates to cost and revenue: •Cost, e.g., energy bill, labour, material (e.g. resources, raw material), maintenance (e.g., facilities), and service fees •Revenue, e.g., sales, income, compensation, Return-on-Investment
Policies and regulation	Policy: the activities of the government, members of law-making organizations, or people who try to influence the way a country is governed, e.g., •Climate agenda/goals •Political focus areas	Regulation: an official rule or the act of controlling something, e.g •Laws •Regulations •Incentive/compensation scheme

- ***Technology transfer possibility investigation.*** With the identified commonality and variability of the chosen business ecosystems, the potentials of exporting the targeted technology from one ecosystem to another and the conditions can be identified. Furthermore, strategies for technology localization can be investigated and evaluated based on the result.

Future works

As described above, each of the three aims has its focus. Therefore, three sub-methods should be developed correspondingly. Meanwhile, related activities and expected outcomes should be presented and explained with cases and examples of energy ecosystems. It can facilitate the understanding of the method and applications in the energy sector. Furthermore, the correlation with other parts in the business ecosystem modelling framework should be introduced and explained to provide coherence of the whole framework.

Authors' contributions
The author read and approved the final manuscript.

Declarations

Competing interests
The authors declare that they have no competing interests.

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