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Doctoral School of Business and Management

SUMMARY OF THESES

Máté Zavarkó

Change management models induced by disruptive energy technology development

PhD dissertation

Supervisor:

Dr. habil. Zoltán Csedő

Associate Professor, Head of Department

Budapest, 2021

Institute of Management

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Contents

I. Research background and justification of the topic

Actuality and relevance of the topic

The energy sector is going through a global transformation and based on the foundations of the contingency theory (Burns & Stalker, 1961), this changing environment means pressure for companies in the energy sector for adaptation and renewal. Renewal needs innovation, but the innovation-focused change management is difficult because of strategic (March, 1991; Duncan, 1976; Burgelman, 1991), structural (Dobák, 2002; Bartlett & Goshal, 2002; Csedő, 2006), capability-based (Grant, 1996; Teece, et al., 1997), and managerial (Beer & Nohria, 2000; Dobák, 2002) dilemmas (Csedő & Zavarkó, 2019b). This complexity is increased by two further factors. First, even though disruptive technologies with their novel value creation can change the dynamics of an industry, yet they are less attractive for (large) companies for investments because of their prior inferior performance compared to well-known technologies (Christensen, et al., 2015). Second, because of the rigid external (institutional) and internal (organizational) factors in the energy sector (Csedő, et al., 2018), disruptive technology development can face serious obstacles, even in cases when it would be clearly required for environmental adaptation. Consequently, it is important to create or extend organization and management models for the top managers of energy companies that can support change management for disruptive technology developments.

If we examine changes in the energy sector one step closer to the concrete opportunities and challenges, we can find new technologies that can be key solutions to the future energy sector according to the scholars and professionals, as well. One of these is the power-to-gas (P2G) technology, through which the surplus electricity (produced by renewables in the peak period) can be converted into a gas product, that can be efficiently transported through the natural gas grid or stored for later use (Götz, et al., 2016; Csedő, 2019). Based on my personal interests, motivation, and the topic's environmental, social, and economic context I formulated the following research question:

What organizational changes are induced by a disruptive energy technology development (power-to-gas technology development), and what models can be used to lead these changes for the widespread, commercial-scale implementation of the technology?

The theoretical focus of my PhD research introduced by my research question is the organizational changes, their conscious management, i.e., change management (Dobák, 2002; Csedő, 2006), which I examine from the perspectives of innovation and knowledge management by building on the main theories of the resource-based view of the firm (Barney, 1991; Teece et al., 1997; Grant, 1996). Answering the research question has theoretical and practical significance as well, as my PhD research aimed to examine former change management theories from the aspect of organization theory, and also to systemize and (re)interpret them based on the empirical results gained in the energy sector. Since the general renewal challenges and the particular managerial challenges of the disruptive technology development lead (led) to the open innovation (Chesbrough, 2003), the main theoretical contribution of my PhD research that it offers a new perspective and

model for examining the relationships of disruptive technology development, open innovation, and change management.

I also go beyond the disruptive technology-related and P2G-specific international research in a few points with my disruption- and management-focused PhD research. The reason for that, although in the last couple of years the international literature has been assessing more intensively the potential effects on the energy sector and the research and development results of the innovative power-to-gas technology (Blanco & Faaij, 2018; Zavarkó, et al., 2018), P2G research does not focus on the management challenges of the innovative technology development and implementation. This topic is important not only from a theoretical perspective, but in practice as well, because the extensive, industry-wide implementation of the promising methanation technology has yet to happen (Ghaib & Ben-Fares, 2018; Blanco & Faaij, 2018).

The effects of organizational theories on the research of change management

I presented in my dissertation that functionalist and interpretative paradigms are built on opposing assumptions, and in my case, the interpretative, qualitative approach supported the wider functionalist goals and answering a functionalist question. To dissolve the contradictions, I chose my methodological tools accordingly (extended case study method, coding technique of grounded theory). Moreover, I assessed the possible interpretations of the theoretical models of change management – and also innovation and knowledge management models as complementary aspects – with my supervisor, from the perspectives of interpretative and positivist science, interpretative and functionalist organizational theory, based on assumptions that are ontological, epistemological, about the human nature, and methodological (Burrell & Morgan, 1979). Finding suggests that in the theoretical models that shaped our thinking, assumptions that can be contradictory from perspectives of certain paradigms (could) have played important roles because these result in satisfactory solutions for (1) understanding of the complex organizational reality and (2) guidance for better managerial performance. (Csedő & Zavarkó, 2019a)

Theoretical framework

Based on the literature review about the strategic background of change management, the considerations from organizational theories in the area of change management and the integration of opposing approaches, I created the following theoretical framework to contextualize my research and clarify its focus (Figure 1). The figure primarily points out that my theoretical framework is built on contingency theory, thus, in a changing environment adaptation is necessary for organizations. For adaptation and innovation, organizational change and change management can be required. Moreover, the implemented technological innovation can impact the environment, and if the new solution is disruptive, it can fundamentally influence the dynamics of the industry.

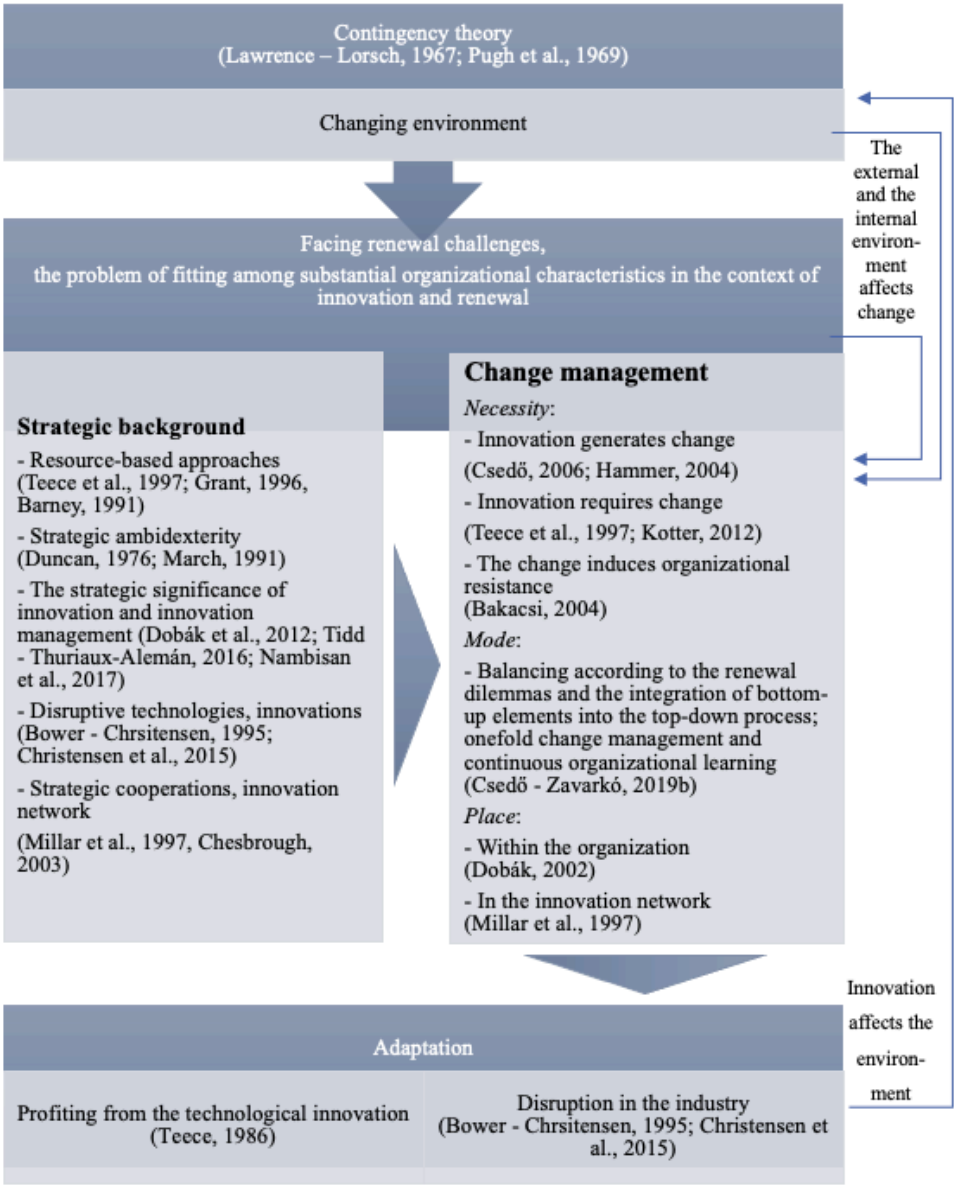

Figure 1. The theoretical framework of my PhD research

Source: *own construction*

II. Applied methods

I built my PhD research strategy on qualitative research methodology, and I conducted multiple case studies within the framework of action research. While conducting the case studies, I gathered company documents, conducted semi-structured individual and focus group interviews. To process the data (1) I used qualitative content analysis, for a prior inductive understanding, (2) I made techno-economic analyses based on quantitative data in line with the functionalist foundation, (3) I used the coding technique of grounded theory to be able to build or complete theories based on empirical data. My research had a central case at the disruptive technology (P2G) developer company, where I conducted an *extended case study.* This is a type of case study with a deep analysis of the company and a retrospective approach (Burawoy, 1998; Danneels, 2010). Besides the central case, I conducted peripheric case studies at the companies that can be potential sites for the technology, which provided new viewpoints to answer the main research question.

Three research sub-questions oriented the case studies (Q1-3), which were useful to answer the main research question (Q4). Through the research, it was an important goal to empirically analyze the central topic and the main research question from several perspectives of the theoretical framework and the P2G-specific literature along the research sub-questions, thus supporting theory-building. In accordance with the qualitative methodology and action research, I did not define hypotheses, but theoretical, propositional knowledge (hereinafter: presumptions) for the research sub-questions and the main research question. This is because in case of action research, it is important to support practice with existing theories, but also to develop new theories that are built on practical experience (Coghlan & Brydon-Miller, 2014). I present the research sub-questions, the related presumptions, and the theses in Section III. In addition to document analysis and data request forms, 32, approx. 1-hour long interviews were conducted, most of which I attended with my fellow researchers. Since my research primarily focuses on organizational change and change management from the management sciences, I built my action research process on the three-stage model of Lüscher and Lewis's (2008) research that was also focused on organizational change and published in the Academy of Management Journal. In the case of my PhD research, the three stages of the action research were the following:

1. Preliminary fieldwork (2017-2018): Document analysis and qualitative content analysis
2. Intervention (2018-2020)
    a. Extended case study: 18 interviews and document analyses
    b. Peripheral case studies: 14 interviews, data request forms, and site visits, consultations
3. Theory-building (2020-2021): Analysis and synthesis of results.

I continued to collect data until I reached theoretical saturation (Glaser & Strauss, 1967), but the number of the interviews are in line with the literature, as well (Danneels, 2010; Bingham, et al., 2015; Tripsas & Gavetti, 2000).

III. Results

In the phase of the preliminary fieldwork, I aimed for prior understanding and I pointed out that the focal technology development has innovation potential in Hungary. Moreover, the smaller technology developer companies and large energy companies participating in the development process can have complementary resources (e.g., innovative core technology – extended infrastructure and resource base) and contradictory organizational characteristics (e.g., dynamic, project-based operation – strong hierarchy and strict regulations). These findings oriented the case studies of the intervention phase, the sub-questions of which (Q1-3) and the main research question (of the theory-building phase) (Q4) were supplemented with presumptions based on the literature (P1-4). The theses (T1-4) fine-tune and extend the presumptions with new aspects, they do not refute them. This result is consistent with the chosen methodology, the iteration between theory and practice, the literature, and empirical data collection and analysis.

First research sub-question, presumption, and thesis

During the peripheric case studies, I researched the environmental and organizational changes related to the focal technology development with an "outside-in" approach, and I dealt with the disruptivity of the focal technology, which is a research gap in the international literature. The first research sub-question was the following:

Q1: What changes are needed for the widespread, commercial-scale application and the disruption of the technological innovation?

Besides organizational change and change management, the presumption for the research sub-question considered the examination of the disruption as well, because it also appeared in the main research question.

> P1: The focal technology may become disruptive based on the literature results (Christensen, et al., 2015). The widespread and commercial-scale implementation of a potentially disruptive technology requires organizational changes at the companies that apply the focal technology. This is because technology is a substantial organizational characteristic in the examined organizational context (Dobák, 2002), which changes (must change) owing to the implementation and this affects the other substantial organizational characteristics as well.

To empirically answer the research question, I conducted peripheric case studies at potential sites. The standardized implementation of biomethanation P2G technology of the approx. size of $1MW_{el}$ is promising at larger Hungarian wastewater treatment plants, however, due to the economic aspects, the supportive regulatory environment may also be important for exploiting the potential of P2G. Nowadays, the technology is rather a value innovation due to its unique attribute package (parallel seasonal energy storage and direct decarbonization), while the condition for disruptiveness is a further increase in the volume of renewable energy production and a significant reduction in the costs of carbon dioxide separation (Carbon Capture). These factors are important because the technology would then be able to be implemented on a larger scale with a

favorable cost-benefit ratio even at flue gas emitting industrial plants. Figure 2 summarizes the findings aligned with the research sub-model for the examination of disruption.

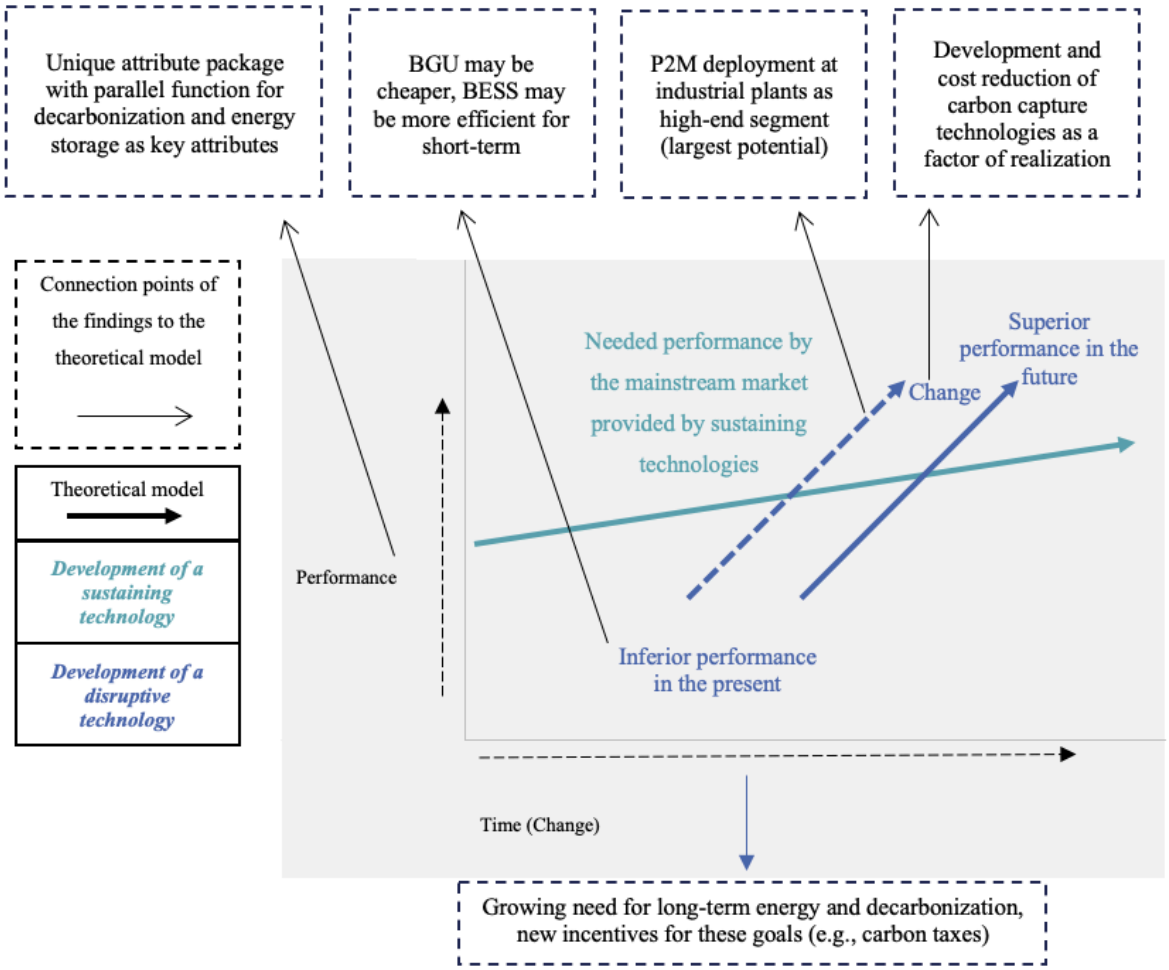

Figure 2. The disruption potential of P2M technology

(P2M: Power-to-Methane; BGU: Biogas Upgrading; BESS: Battery Energy Storage Systems)

(A part of the empirical findings aligned with one of the research models)

Source: Pörzse, Csedő & Zavarkó, 2021

Based on the results, the widespread, commercial-scale implementation of the technology requires not only organizational changes at the sites. The answer to this research sub-question fills technology-specific research gaps and also contributes to theory-building, as potential disruption predicts proactive adaptation through successful technology development, changing the system of environmental conditions.

T1: The focal technology is a value innovation today, however, it can be a disruptive technology of the future depending on complementary technology developments and organizational changes. However, the widespread and commercial-scale implementation of such a potentially disruptive technology requires not only organizational changes. Complementary technology developments must be realized with inter-organizational collaborations and shaping the environmental (institutional) system of conditions for the

widespread, commercial-scale application, and it requires change management beyond internal organizational changes in the case of disruptive technologies.

One of the novelties of the first thesis is that it is the first in the international literature to evaluate the disruptiveness of P2G technology, and to integrate strategic aspects into the study of the technological innovation in addition to technical and economic aspects. From the point of view of management sciences, the novelty of the thesis is that it makes explicit the dependence of disruptiveness on the development of complementary technologies and changes in the regulatory environment, (1) which appears only implicitly in the original model (Christensen, et al., 2015) [1]*, and (2) which goes beyond the necessity of managing autonomous organizational changes, pointing out the importance of managing inter-organizational networks and innovation ecosystems.*

Second research sub-question, presumption, and thesis

After analyzing the necessary changes connected to the examined technology development during the peripheric case studies with an "outside-in" approach, the extended case study conducted at the technology developer startup was prepared with an "inside-out" approach, for which I defined two research sub-questions. One of these research sub-questions was the following:

Q2: What innovation management tasks must be conducted to reach the widespread and commercial-scale implementation of the potentially disruptive technology in the relation system of explorative and exploitative activities?

In line with my research framework, the presumption to the research sub-question is built on the importance of explorative and exploitative learning, moreover, digital innovation and knowledge management.

P2: In order to seize opportunities and address challenges, innovation management tasks, especially idea management, development, learning, and resource and competency management may be required (Tidd & Thuriaux-Alemán, 2016), the efficiency of which can be enhanced by digital innovation management (Nambisan, et al., 2017) and open innovation (Chesbrough, 2003), knowledge and technology transfer (Millar, et al., 1997) between startups and large organizations with complementary resources (innovative core technology – extended infrastructure and resource basis). The determinants of learning and resource and competency management are knowledge management mechanisms that enhance exploitation and / or exploration (March, 1991; Grant, 1996), and these can be supported by digital solutions that enable the codification, systematization, sharing, and utilization of knowledge (Alavi & Leidner, 2001; Zhang & Venkatesh, 2017).

[1] An important element of the theory is that disruption is a process that requires time (and change). The authors cite as an example that new technologies made disruption possible for Netflix. The development of these "new technologies" was not part of the core business model and can therefore be considered as complementary development.

Based on the empirical results, the performance indicators of the focal technology mean value creation opportunities (e.g., efficient long-term energy storage, green gas production, network-balancing) but innovation challenges emerged on micro-, meso- and macro-level (efficiency gains at the technology and sector level, ensuring the conditions for scalability, uncertain regulatory environment). After exploring the operative opportunities and challenges, it became clear that organizational actions are needed to exploit the potential of the focal technology: further research and development, deliberate site selection, access to financial resources, the involvement of experts from other sectors, and change in the regulatory environment.

The dyad-level open innovation (development of the prototype) led to further innovation opportunities (e.g., scaling up the technology, commercial-scale implementation). However, based on the results, a dyad-level collaboration is not enough on its own to overcome the innovation challenges of the disruptive technology. Instead, an inter-organizational innovation network is needed, in which universities, research centers, other startups, investors, state administration also get a place besides smaller technology developers and large companies. In this network,

a) from the aspect of the technology developer company, the parallel realization of exploitative and explorative learning with connecting the actors can be considered as success factors. It means that the company has (had) to affect the external environment as the "engine" of the innovation with the creation of the P2G inter-organizational innovation network.
b) from the aspect of a large energy company, opening the organization for the (disruptive) technology developers are important to facilitate exploration.

These findings are presented in Figure 3 aligned with my inside-outside change model from the theoretical framework. Based on these results, a further success factor can be both in the case of dyad-level or network-level open innovation the support of the technological know-how flow with integrated digital platforms, the functionality of which partly goes beyond knowledge management (know-how development, innovation problem solving – idea generation, prototype / plant management, e-learning).

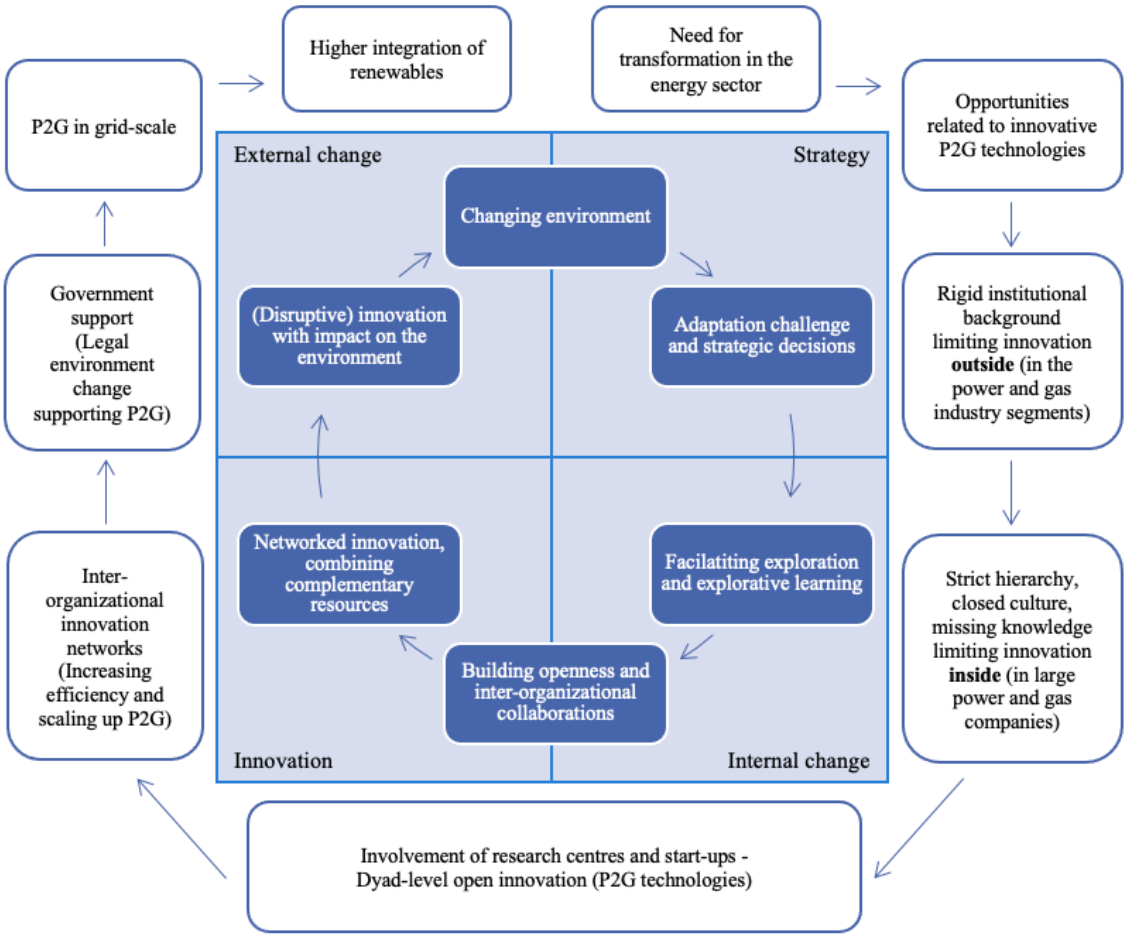

Figure 3. Innovation and change opportunities through P2G technology development
(A part of the empirical findings aligned with one of the research models)

Source: Csedő & Zavarkó, 2020

Consequently, the presumption was correct, but not complete, so I defined the following thesis:

T2: To seize the opportunities and overcome the micro-, meso-, and macro-level challenges of the potentially disruptive technology, dyad-level open innovation is not enough, it is necessary to form an inter-organizational innovation network that has an impact on the change of the external environment. Furthermore, both exploitative and exploratory learning is relevant, not only at the organizational level but also at the level of the inter-organizational network. This learning and the related technological know-how flow can be efficiently supported by an integrated digital platform that provides not only codification, systematization, sharing and utilization, but allows for the flow of knowledge elements between organizations and *also* among modules beyond the scope of traditional knowledge management functions.

On the one hand, the novelty of the second thesis is that it points out the need for generating macro-level change, which was not listed either in the technological or organizational (micro) approach of the list of innovation management practices (Tidd & Thuriaux-Alemán, 2016), or in the network (meso) approach of digital innovation management (Nambisan, et al., 2017). On the other hand, it distinguishes dyad-level collaboration from the inter-organizational network not only as a level of analysis of open innovation

(Chesbrough, et al., 2006) but also as developmental phases of the open innovation structure. It also points out that the knowledge management tools listed in the literature (Zhang & Venkatesh, 2017) need to be expanded for disruptive innovation, both functionally (idea management, prototype management, e-learning) and in terms of users (inter-organizational network instead of a single organization).

Third research sub-question, presumption, and thesis

The need for the inter-organizational innovation network, and the disruptive technology development pointed out that generated change by innovation or the needed change for innovation must be analyzed not only at a single organization:

Q3: What organizational changes are induced by the focal innovative technology development within the stakeholder organizations?

Based on the literature, the realization of the innovation (as a process) and the realized innovation (as an output) can also generate organizational changes, and the adaptation can be supported with partnerships with other organizations.

P3: Among the organizations involved, there will be some that need organizational change for innovation purposes (Teece, et al., 1997; Kotter, 2012), while – through partially open innovation processes (Chesbrough, 2003) – the achieved innovation goal will generate organizational changes in other organizations (Csedő, 2006; Hammer, 2004).

The results showed that P2G technology development and its network implementation induces changes both inside and outside the organizations of the cooperating partners. Collaborating organizations (especially large energy companies following exploitative routines, but also other organizations) "open up" their organizations to each other for the autonomous benefits of P2G (e.g., organizational renewal, adaptation to changing energy trends). This "opening up" also entails organizational changes: the changes observed so far were incremental changes in operational processes, strategy, outputs, and structure, but further changes are (would be) needed (1) the content of which also depends on the capabilities and changes of other organizations involved, and (2) which are necessary for the success of network collaboration (for example, to improve the regulatory environment or to effectively exploit the potential of P2G to the benefit of every partner).

An example for such an aligned change, that the technology developer company expanded its R&D&I focus, in line with the strategic priorities of a large energy company (strategy, outputs), or a new research group started to work in a research center on complementary technologies which can increase efficiency, in line with the solution of the technology developer company (structure, outputs).

In case of further needed changes, alignment is also important for efficiency. For example, the actual implementation of the technology must be aligned with the characteristics of the company that provides the site of the implementation, but this company must modify its processes according to the core technology. Moreover, this complexity is increased further, because this is relevant not only in case of the core technology but complementary technologies as well (which are developed e.g., by dedicated project teams of large

companies or research centers) (process, structure, outputs). If these organizational changes are not aligned, the period of the development, so the invested resources (e.g., workforce) may increase, moreover, redundant, missing, or incompatible results can be produced. Regarding the novelty of the core technology and the complementary technologies, this is a real risk. For example, P2G, Carbon Capture, waste-heat utilization technologies, and related ICT solutions can be developed in several directors, but the related organizational changes (e.g., new R&D process or output, new project team or research group, new operational processes) must be aligned to the shared goals and the autonomous and the complementary (organizational and/or technological) capabilities (e.g., synchronized R&D and implementation of biological methanation, oxyfuel Carbon Capture, low-temperature waste heat recovery and real-time remote control of these). Figure 4 presents the logic of open organizational changes.

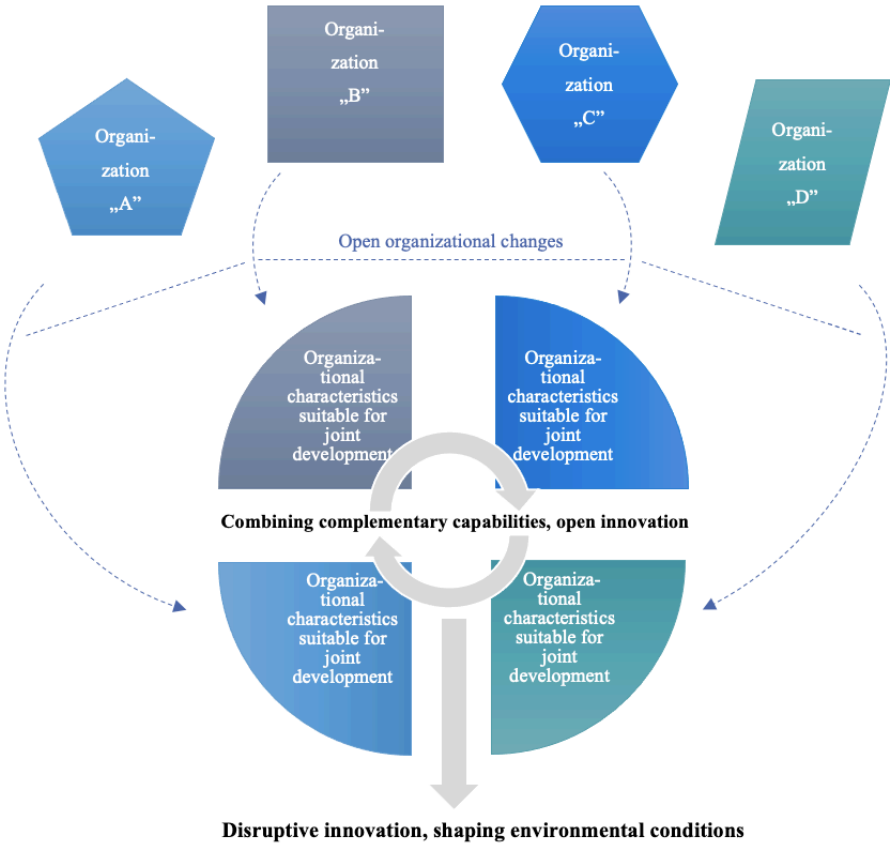

Figure 4. Open organizational change and open innovation in an inter-organizational innovation network

Source: own construction

T3: Because of the novelty (disruptiveness) of the technology, open innovation is no longer enough, the potentially disruptive technology also requires organizational changes in the cooperating organizations. This means that in organizations developing a disruptive technology, organizational change *and* open innovation processes are (can be) interrelated. It is also necessary to align the changes implemented in the different organizations to have a (further) impact on the external environment with the inter-organizational network and to be efficient at the network level. For example: the company which provides the physical infrastructure must reconfigure the operational process according to the core- and complementary

technology developers' capabilities for the implementation; (2) a large energy company and a research center must share the complementary R&D&I tasks according to the core technology and the specific attributes of the infrastructure-provider, and creating project teams and research groups. The efficiency of the development is higher when organizational changes are aligned because the period, so the invested resources can be decreased in this way, moreover, no redundant, missing, or incompatible organization outputs are produced in the network.

The novelty of the third thesis is that open innovation not only requires or generates organizational changes in collaborating organizations (Peris-Ortiz & Liñán, 2019)*, but these changes must also be aligned because of the goals of the inter-organizational network and efficiency expectations.*

Main research question, presumption, and thesis

Along the three research sub-questions presented, I approached my research topic from several aspects (environmental change and strategic alignment; resource-based examination; analysis of technical, economic, strategic issues and disruptiveness; technology-specific innovational opportunities and challenges; innovation management tasks; organizational changes), to cover every aspect of my research question with my research.

Main research question (Q4): What organizational changes are induced by a disruptive energy technology development (power-to-gas technology development), and what models can be used to lead these changes for the widespread, commercial-scale implementation of the technology?

Based on the analysis of change management theories and their (re)interpretation, I defined the following presumption:

P4: Disruptive energy technology development (power-to-gas technology development) can induce incremental and/or radical organizational changes. The changes induced by technology development can be managed according to the following models: (1) top-down organizational planning and type "E" change, (2) bottom-up organizational development and type "O" change, (3) combined model (one top-down and one bottom-up element each) or (4) an integrated model (integration of bottom-up elements into the dominantly top-down process). (Dobák, 2002; Beer & Nohria, 2000; Csedő & Zavarkó, 2019b)

Based on the results of my empirical research, the models presented in the "Change Management" chapter of the "Theoretical Framework" part of the dissertation are in fact about "*one-dimensional change management*" and "*closed organizational change*". It means that the change management conducted by top managers only considers the context and substantial characteristics of the own organization and only aims to change the substantial characteristics of the own organization. However, in the context of P2G technology development, I identified that when developing (potentially) disruptive technologies in an inter-organizational innovation network, the management of organizational changes *generated* or *made necessary* by innovation happening at different stakeholders needs to be aligned so that network members realize greater profit as quickly as possible through their joint developments and investment of resources. This means that the top management of each organization must consider (1) the capabilities of the cooperating partners, (2) possible organizational changes

taking place in parallel at the partners, (3) the common goals of the cooperating partners; (4) and they must also align these, in addition to (A) leading the internal change along with the strategic and innovation goals of the own organization and their substantial organizational characteristics, (B) and thus, allowing for the autonomous renewal and environmental adaptation of the organization.

If one-dimensional change refers to a single (own) organization, then in the case of organizational changes aligned to a single collaborating partner, we need to talk about two-dimensional change management, in the case of alignment to two partners, three-dimensional change management, and so on. Because *multidimensional change management*

a) is relevant in the case of the analyzed disruptive technology due to the necessity for open innovation,
b) involves the alignment of changes of the organizations in line with the goals of the network, the capabilities, and changes of the partner organizations,

thus, we no longer just talk about closed organizational change, but – by analogy with open innovation – about *open organizational change*. Importantly, the ability to change one's own organization is an essential condition for changes aligned to the collaborations, i.e., multidimensional change management *cannot be imagined* without one-dimensional change management. According to the concept of multidimensional change management, disruptive innovation that has a significant impact on the external environment and shapes the system of environmental conditions requires an inter-organizational innovation network; and as innovation involves organizational changes, their management in the network needs to be aligned by the top management of the organizations. Aligned organizational changes allow organizations with complementary capabilities to combine these capabilities in a way that results in a disruptive innovation that has a significant impact on the external environment. It is important to emphasize, however, that multidimensional change management in an inter-organizational innovation network *does not necessarily mean that all participating organizations need to change at the same time or with certainty*, but rather that, each organization must consider the characteristics of the other organizations, the shared goals, and the *possible* current or future changes of the partners during the autonomous organization change.

Main thesis (T4): A disruptive energy technology development (power-to-gas technology development) has generated incremental changes in various substantial characteristics of several organizations and requires further changes in the inter-organizational innovation network. These can be managed by a "one-dimensional" and a "multidimensional" change management model, the latter involving "open" organizational change. To implement the disruptive technology as quickly and efficiently as possible, widely and on a commercial-scale, a new, multidimensional change management model should be followed instead of the "traditional", "one-dimensional" change management models.

Based on the theoretical models described in the "Change Management" chapter and extended, the main features of one-dimensional and multidimensional change management are presented in Table 1, and I analyze the novelty of the thesis in the last section.

	One-dimensional change management	Multidimensional change management
Trigger	Loss or threat of loss of the environment-organization fit	Loss or threat of loss of the environment-organization fit **Open innovation, aiming at disruptive technology development**
Goal	Organizational renewal, environmental adaptation Ensuring environment-organization fit (proactive, preactive or reactive adaptation)	Organizational renewal, environmental adaptation Ensuring environment-organization fit, **significant effect on the external environment,** shaping the system of environmental conditions (proactive adaptation)
Context	Strategic, structural, capability-based, and managerial dilemmas	In addition to strategic, structural, capability-based, and managerial dilemmas, there are also **collaboration dilemmas** (e.g., giving up on short-term organizational benefits to maximize network benefits)
Content	Management of closed organizational change: Identifying, preparing, planning, implementing, and maintaining the necessary changes for the own organization	Management of **open** organizational change: Recognizing, preparing, planning, implementing, and maintaining the necessary changes in an **inter-organizational (innovation) network, in cooperation with other organizations, in accordance with the objectives of the cooperating network and the organizational characteristics and / or changes of its members**
The key to renewal in a conti-nuously changing environ-ment	Dynamic capabilities: a) sensing the opportunity, b) seizing the opportunity, c) transforming. Managing efficient and flexible knowledge integration processes, overcoming knowledge retention within the organization.	Dynamic **co-**capabilities: a) sensing the opportunity *for cooperation*, b) seizing *together* the opportunity c) *aligned* transforming. Managing efficient and flexible knowledge integration processes, overcoming knowledge retention within the **inter-organizational innovation network.**

Table 1. One-dimensional and multidimensional change management

Source: own construction

Organizational theoretical analysis of the main conclusions

In the first half of my dissertation, by analyzing some of the outstanding change management models in the literature, I pointed out that combining elements which are contradictory from the perspective of the philosophy of science can be useful for creating theories that support complex managerial tasks. This conclusion also seems to be a relevant factor in further research on models of multidimensional change management and open organizational change. Thus, conducting the organizational theory analysis regarding the main conclusion is also worthwhile.

Possible functionalist assumptions of open organizational change and multidimensional change management:

a) Realism: There is a system of "external" environmental conditions (stable structure) that can be affected by the disruptive innovation created by multidimensional change management.
b) Positivism: A general causal relationship is that multidimensional change management leads to open organizational change in an inter-organizational innovation network, which together can enable disruptive innovation.
c) Determinism: The adaptation pressure as a situation determines the commitment of the organizations and top managers (as individuals) participating in the network towards the joint innovation activity and aligned change.
d) Nomothetic methodology: The characteristics of open change can be examined at the network level by action-reaction analysis, it is not necessary to examine the autonomous organizational realities in depth. The success of multidimensional change management can be measured by breaking it down to its elements (organizations) of the cooperating network as a system, by examining the autonomous and collective performance of the system elements.

Possible interpretative assumptions for open organizational change and multidimensional change management:

a) Nominalism: If strategic and innovation goals are influenced by changes and further changes are needed to achieve these goals, moreover disruptive innovation and proactive adaptation generate further change, then change can be considered continuous, i.e., there is no stability and permanence, and thus, there is no "external" structure to grasp.
b) Anti-positivism: The autonomous change management strategy of multidimensional change management for a given organization cannot be established universally, it can only be defined in a given organizational context.
c) Voluntarism: If individuals and organizations can influence the environment by changing themselves and through their joint (disruptive) innovation activities, then the situation does not unilaterally define behavior.
d) Ideographic methodology: The characteristics of open organizational change can only be known in the natural context of autonomous organizational change, by direct data collection, in the field, by analyzing the background influencing autonomous organizational behavior in depth.

Furthermore, the synthesized functionalist and interpretative-functionalist (one-dimensional) definitions of change management can be extended to multidimensional change management:

a) Functionalist approach: The role of multidimensional change management is to implement the open organizational changes required for disruptive innovation to achieve proactive adaptation by modifying autonomous organizational systems in a way that is aligned to the collaborating organizations.
b) Interpretative-functionalist approach: The role of multidimensional change management is to support cooperating organizations through continuous organizational and environmental change, to gain a deeper understanding of the factors behind change and the characteristics of open organizational change (motivations, shared meanings) through personal leadership, and to modify these factors for

the purposes of the inter-organizational innovation network. (The definition will become functionalist through the "modification".)

Theoretical contributions of the main conclusions, limitations, and future research directions

The relevance of the topic and the theoretical contribution of my research to the development of the field can be justified on the one hand by the fact that based on the bibliometric analysis of Odriozola-Fernández et al. (2019), neither change, organizational change nor change management appears amongst the most common keywords of publications concerned with the topic of open innovation regarding small and medium-sized companies (startups). Filling this research gap in part, the results of my PhD research – analyzed primarily from the perspective of a smaller technology developing startup – envisage the need for aligned autonomous organizational changes of the partners cooperating in innovation. On the other hand, Fernandes et al. (2019) identified six theoretical perspectives on open innovation based on a comprehensive literature review: (1) the concept of open innovation, (2) open innovation and networks, (3) open innovation and knowledge, (4) open innovation management, (5) open innovation and innovation spillover, (6) open innovation and technology. While my PhD research considers these theoretical perspectives, especially the importance of networks, knowledge, and management, it also identifies a new theoretical perspective for further research: “open innovation and change management”. It is also worth noting that none of the literature reviews cited contain the term “disruptive,” which was also an important pillar of my research.

Although it is not possible to state with certainty given the almost unlimited amount of literature available today, but I hope that the concepts of “multidimensional change management” and “open organizational change” as the main theoretical conclusions, which are presented with a more developed and novel content based on the literature research, especially the considerations behind them, can be forward-looking in the development of the field of change management.

Building on action research, case study approach, and grounded theory, the conclusions can be considered as a substantive theory (Glaser & Strauss, 1967), which is valid in a given research context. Although the theoretical conclusions and propositions presented are based on iterations of empirics and theory, there are still several change management questions that require new research in order to be answered. Examples include how to realize multidimensional change management in practice, what are the challenges of collaborations, and what tools can be used to address them? As the environment of my PhD research, P2G technology development was not (yet) adequate to research these questions, in the short term it is possible to answer these questions and test the theoretical propositions only in other areas. Moreover, given the nature of multidimensional change management, it may be necessary to analyze the highest level of organizational leadership, the corporate governance literature, to answer the new questions.

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