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Contract Design: A Key for Adopting Discontinuous Innovations in Socio-Technical Sustainability Transitions

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***Abstract*—**The transport industry is transitioning to sustainable industrial systems to meet its environmental targets. At the heart of this transition lies the electrification of bus systems, which involves the introduction and testing of sustainable technologies in protected environments for customer evaluation. While the transition necessitates business-model innovation, practical implementation has proven to be complex. This article delves into efforts to present the business model of a bus operator engaged in public procurement with the goal of facilitating the industry's shift towards electrification. Through an in-depth case study, the influence of public contracts' design on the evolution of a technology and the operator's business model for electrification is explored. While the extant literature suggests that public procurement can facilitate business-model innovation and sustainable development, the findings reveal that public-contract design can limit value creation and value capture in potential business models, locking organizations into existing business models and hindering the socio-technical transition to sustainability. Interestingly, public-procurement contract design can play a pivotal role in preventing sustainable innovations from breaking through. This highlights the importance of contract design as a vehicle for dialogue between businesses and authorities that can enable systemic change. The case study also illuminates a paradoxical scenario in which the transport authority was required to reconcile the efficiency and stability required for bus transport with the potential benefits of electrification technologies promising sustainability. Finally, recommendations for navigating and addressing this tension are provided. The implications of these findings extend to the literature on discontinuous innovation and business-model innovation.

***Keywords*—**Sustainable transition, public procurement, business-model innovation, discontinuous innovation, lock-in.

I. Introduction

INDUSTRIALIZATION has yielded increasingly stable and more prosperous societies over the centuries. However, global warming is a cost of industrial success and, by all accounts, poses an imminent threat to the survival of the human race. The transport sector has come into the spotlight because of its substantial economic and environmental impact, and environmental targets have been set to control those effects. Nations around the world have enacted environmental targets that industries must meet. For example, Sweden has pledged to cutting its net carbon emissions by 100% by 2045 [42], with a specific goal to reduce emissions from domestic transport by 70% between 2010 and 2030 [32].

Bus transportation is at the epicenter of the socio-technical transition to sustainability and bus-fleet electrification is moving forward around the globe. This article focuses on Sweden, where bus transport is organized through public-procurement contracts with transport authorities. The bus operator studied in this article engaged in a multi-stakeholder project in Sweden that aimed to test an inductive smart-charging bus system. This system was based on wireless electric charging, which occurred while the bus was running rather than during non-operational periods.

According to the multi-level perspective on system innovation [20], the new environmental targets represent interventions that challenge the current socio-technical transport regimes (e.g., buses, cars, trucks). These regimes encompass not only firms, technologies, and the activities of engineers but also such social groups as users, policymakers, and civil-society actors [20], [22]. Such interventions may trigger a shift to a new socio-technical system that is more efficient environmentally [21], [23]. Therefore, pilot projects have been introduced around the world to test alternative and sustainable technologies. However, these projects face strong resistance from stable regimes.

Sustainable innovations create uncertainty about prices, performance, demand, and impact. This uncertainty gives rise to complications for thinking, analyses, calculations, and models, including business models. Such innovations are revolutionary, as they entail completely new products and services [48], [57]. In fact, they are usually discontinuous in the sense that they bring a substantial degree of change, and they can be described by their scale, results, and irreversibility [3], [13]. Such radical changes exert pressure on the business models of the actors who are encountering such shifts. Customer value is pivotal in scaling the discontinuous innovations [29], [38], [50]. Furthermore, the incumbents' business models become problematic because current practices are challenged by sustainable technologies [6]. Therefore, incumbents may be required to change their business models to unlock the economic value in innovations [9].

Business Model Innovation (BMI) may be necessary to accommodate sustainable technologies. In the case of public procurement, business-model innovation can be triggered by either public actors' demands or the private side's desire for economically efficient solutions [31]. However, when transitions are underway, the potential business models of

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incumbents are unclear [43]. A scholarly understanding of the dynamics of business models undergoing transition as a feature of a wider industry transformation has not been adequately pursued thus far [37].

To investigate the dynamics of business models concerned with discontinuous innovation in the context of socio-technical transitions, a public bus operator's business model is examined as well as BMI attempts to facilitate the discontinuous innovation—an electrified bus system. The research question is as follows:

- RQ: How is business-model innovation for discontinuous sustainable innovation handled in public-procurement processes?

An answer to this question would promote the development of approaches to public-procurement contract design that could facilitate the adoption of sustainability-related discontinuous innovations using business-model innovation.

II. Theoretical Background

A. Socio-Technical Transitions: A Multi-Level Perspective

A transition process is a shift from one socio-technical system to another. In other words, the current trajectory is not reoriented but a new one is adopted. This translates into changes in elements of socio-technical systems, including the knowledge base, technologies, infrastructure, regulations, and user practices [23]. This perspective relies on the view that a technological change on its own is not sufficient to drive the large-scale changes required for a transition. Therefore, a transition is viewed as an overarching process resulting from interactive processes occurring on multiple levels [25]. In this regard, a dynamic multi-level perspective (MLP) on system innovation is adopted [20], which is illustrated in Fig. 1.

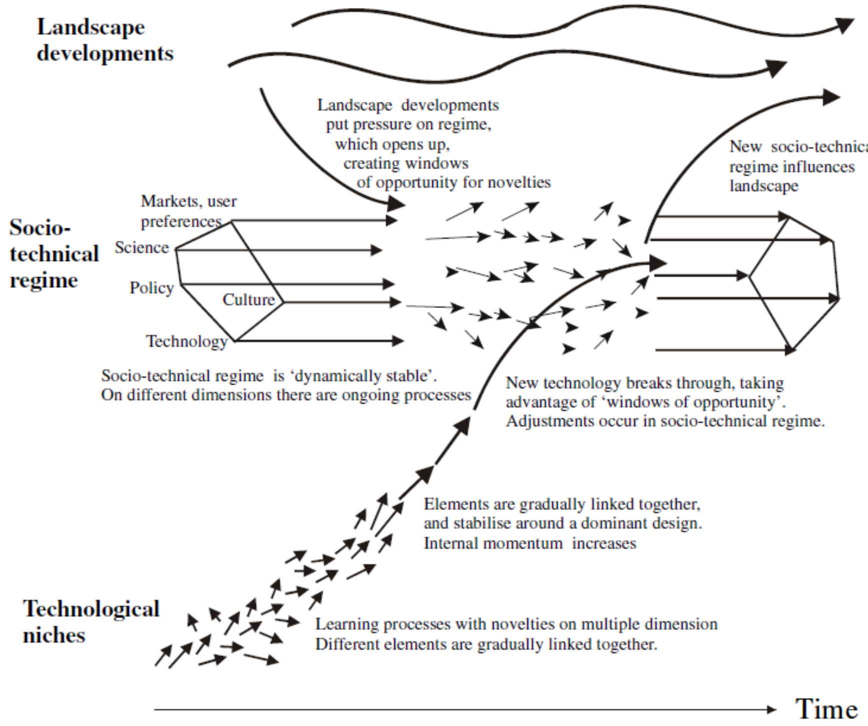

Fig. 1 A dynamic MLP on system innovations [20, p.1263]

Transitions are often driven by innovations that develop in small niches to satisfy particular uses. These innovations are held in protected spaces, such as pilot projects and experiments, that replicate real-life conditions and allow for better learning. Innovations in niches focus on the geographical area, a new technology, or special government interventions. As such, they are formed by external events that shape the expectations and strategies of companies and governance [24].

Innovations engender disruptive technologies that interrupt a conventional path of performance development or radically redefine what performance means [11, p.202]. Such technologies exert a major impact not only on industrial success and growth but also on sustainable development [18]. Moreover, the value proposition for customers changes radically when disruptive technologies are introduced and pave the road to sustainability [10], [50].

B. Discontinuous Innovation

Changes brought about by innovation can be either continuous or discontinuous. While continuous change does not initiate dramatic shifts, discontinuous change brings about an irreversible new order [8], [52]. Innovations developed in niches are intended to be radical, as they encompass certain technical knowledge on how to do things better than the status quo [40]. A discontinuity involves a substantial change, and can be described by its scale, results, and irreversibility [3], [13]. A discontinuous change is game-changing because it entails

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completely new, unfamiliar products and services, especially with respect to how they should be used [48], [57].

The literature on disruptive and discontinuous innovation indicates that the customer is the decisive factor for success. Discontinuous innovation begets unusual, creative, and effective ways to create breakthrough value for customers [29]. Consequently, the customer is the cornerstone when it comes to the success of such an innovation. Moreover, success and market acceptance in discontinuous innovation (i.e., acceptance, awareness, and use of product) require a compelling customer value proposition [51].

In terms of sustainability, a certain niche customer segment will prefer a more environmentally friendly solution even if the performance is sub-optimal when compared to traditional solutions. Eco-niches are medium-sized market segments occupied by "bioneers" (a portmanteau of "bio" and "pioneer") who try to discover market niches focused on eco-products in which they can market their innovations [38]. The principal characteristics of such segments are a preference for high environmental protection, and an ability and willingness to pay.

As the customer and customer value are pivotal in an innovation's success, business models that meet customer needs and capture value for the firm are vital. Technologies are not, in themselves, enough. Business models are important parts of the puzzle when it comes to disruptive innovation [36], [43].

C. Business Models and Business-Model Innovation

The business model examined in this article involved three key components covered in the literature: value proposition, value creation, and value capture. These dimensions were derived from existing frameworks, and sub-components were further adapted from the literature [9], [28], [33], [41] to help visualize the key aspects that are relevant in discontinuous sustainability-related innovation.

The customer value proposition formulates the value created for users by the offering. This is a problem of fundamental proportions. To design the offering, firms need to understand the customer's job and all of its dimensions, including how it is handled [9], [28]. Value creation refers to the key activities and processes within the firm's value chain. Its main sources are novelty, efficiency, complementarities, and lock-in [2], [58], [59]. Finally, value capture denotes how the company creates value for itself while delivering value to its customers [28]. Table I shows the main components and sub-components of the business-model design examined in this article.

TABLE I
BUSINESS-MODEL COMPONENTS

Value Proposition	Value Creation	Value Capture
Product Service Segment	Key activities Technology Partners Resources	Cost structure Revenue model Resource velocity

To facilitate the transition to sustainability, business models must often be changed. Accordingly, BMI must typically accompany technological innovations to ensure original and sustainable value-creation opportunities [44]. Notably, decisions about BMI seem risky due to the uncertainty caused by the complex interrelations between technological developments and BMI [54].

In a public-procurement context, BMI may be prompted by demand from public actors for innovative solutions and partnerships. It is carried out by the private firms motivated by business goals related to efficiencies and the desire to become more competitive in public procurement [31]. To win such contracts, innovative solutions should integrate technological and sustainable aspects [31]. In this regard, public procurement can help facilitate innovative business models that reduce barriers to sustainability and enable private companies to gain a competitive advantage while being sustainable [34]. Therefore, public procurement can be a valuable tool for facilitating sustainable development [16].

BMI varies from incremental changes in one or two business-model-design aspects influenced by the regulatory regime [27] to fundamental changes in the entire business model [5]. With transitions like the electrification of transport, business-model alterations in all three components seem necessary to support the new technologies and, thereby, sustainable innovation [19] [5].

D. Path Dependency and Lock-in

Path dependency is a rigid action pattern resulting from unexpected consequences of past decisions and positive feedback processes. In other words, history matters. Past events guide future action and decision-making, which are characterized by persistence and lock-in [39]. Path dependency is a natural process based on two conditions—contingency and self-reinforcement—which cause lock-in in the absence of exogenous shocks [47]. This distinguishes the process of path dependency from the outcome of lock-in.

Incumbents tend to become locked into their paths due to self-reinforcing mechanisms that contribute to the development of those paths. This pattern is usually accompanied by actual or potential inefficiencies. Lock-in occurs in three phases. In phase 1, which starts with contingency, there is an acute event or decision that favors a solution leading to a critical stage. If this triggers a regime of positive self-reinforcing feedback, then the solution becomes persistent. At this point, phase 2 starts. The path is likely to be replicated and thereby phasing out other alternatives to some degree. Phase 3—the lock-in situation—then arises [39]. Fig. 2 presents the three phases that lead to lock-in.

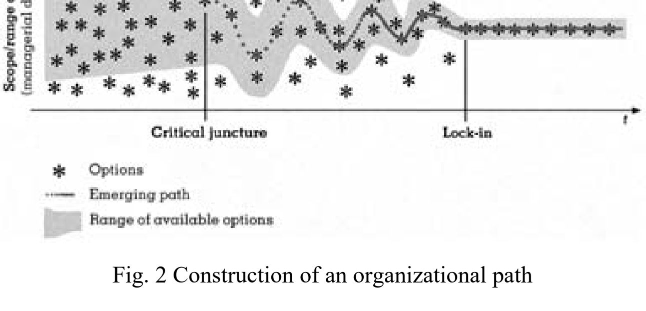

Fig. 2 Construction of an organizational path

III. Research Objectives

Transformations tend to be driven by discontinuous and disruptive innovations, and customer value is often the decisive factor when it comes to the evolution of an innovation. The customer plays a pivotal role in the success of a discontinuous innovation, as the innovation introduces an unusual, creative, and effective way to create breakthrough value for the customer [29]. Moreover, although disruptive technologies offer the promise of value from penetrating current and new markets, the success and failure of such technologies hinges on customer resistance [50]. Indeed, success in mainstream customer markets is required to establish an environment in which competition is focused on fulfilling customer preferences [38]. Sustainable innovation is needed for sustainable development. Suppliers of environment-related innovations —bioneers— focus on customers with sustainability-focused preferences and a willingness to pay.

A question arises as to whether the customer may be the deciding factor in a public-procurement situation, as the customer is bound by the rules included in the contracts. In other words, what happens to the business-model design in transitions that lead to industry transformation? [37] In this article, this topic is examined using a single case study that investigates business-model dynamics for discontinuous innovation, and further analyzes how public contracts are shaped to and accommodating of the sustainable-innovation path.

IV. Research Design and Methods

To explore the challenges presented by business models, an inductive case-study approach is adopted. The decision to analyze the inductive smart-charging bus system was motivated by the system's ambitions to improve sustainability and the public-private collaboration established to advance such a system. The case inspired new ideas through immersion in rich data, which promoted an in-depth understanding of a complex social phenomenon [15], [56]. The unit of analysis for this study was the potential business model of a key actor operating in the system, and the potential effects highlighted by the pilot project were reflected.

Semi-structured interviews served as the main data source. The process started with interviewing representatives of the stakeholders working closely with the inductive smart-charging bus system and then undertook more in-depth interviews with the bus operator's personnel. In total, 24 interviews were conducted, lasting approximately one to two hours each with business strategists, market strategists, engineers, and project managers (see Appendix 1 for more details on the interviews). The interviewees and their views improved the understanding of how the technology worked, the systemic aspects of the innovation, and the operator's existing and tested business models. The interview data were triangulated with data from other sources, like project reports, websites, and annual report(s) from the operator and business partners to ensure the data's validity.

Data analysis and data collection were undertaken simultaneously due to the ethnographic nature of the research [17, p.13]. First, the business-model framework in Table I was applied to the data collected about the bus operator's business under the extant system. The same approach was applied to the operator's potential business model under the envisioned system. In a second step, a comparative analysis of the extant business model and the envisioned model was conducted by tracing how business-model processes would be affected in the new business model when compared to the extant model. Three types of impacts were highlighted: positive, negative, and mixed.

This article was written after the cancellation of the inductive smart-charging bus system pilot project — a system that promised significant value and sustainability for the transport sector and its operations. This provided an interesting opportunity to understand why and how such a promising disruptive technology failed in the niche phase.

V. Results

The inductive smart-charging bus system pilot project was launched in December 2014 and ended in December 2017. It aimed to test and evaluate the potential of an inductive, electric-hybrid bus in real traffic through the installation of charging infrastructure on roads located in Södertälje, a city located south of Stockholm, Sweden. This bus-transportation system held out the promise of an alternative bus solution that would reduce noise, cut CO_2 emissions, improve energy efficiency, and decrease fossil fuel dependency through electrification. Fig 3 displays a street section and shows the location of the charging unit under the bus stop.

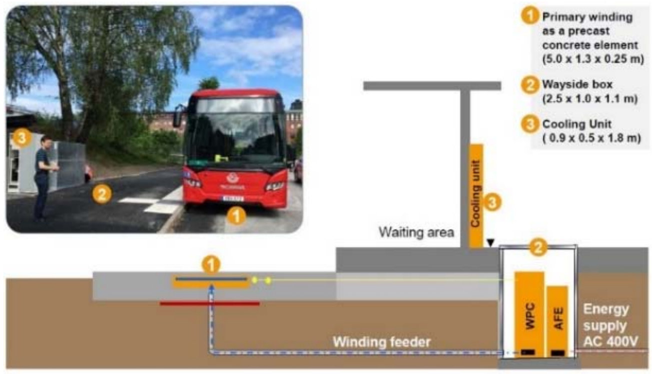

Fig. 3 Street cross-section and the inductive charging unit

The actors participating in the pilot were: i) a global OEM leader that provided transport solutions, including trucks and buses; ii) a Swedish-owned utility company responsible for procuring, managing, and installing the charging stations; iii) a public-transport authority in the Stockholm region; iv) Transport Research Lab — a research lab focused on future transport solutions; v) a municipality south of Stockholm, which hosted the project-related activities and provided support for the installation and operations; vi) a manufacturer of aircraft and trains; and vii) the largest public-transport operator in the Nordic countries. The operator's business model was the main focus of the study.

The public-transport operator was presented with a new business model to be tested in the project. In this process, the operator along with the other partners (mainly the transport authority) considered the new business model. They discussed and tested the model's feasibility and viability, and compared it to the traditional business model. A bus-fleet manager at the operator referred to this as one of the project's purposes, stating: "This new charging technology for the bus entails a new way of offering and operating the bus business that we need to evaluate and discuss internally, and within the project. We need to make a decision as to whether to adopt this or keep the current way of charging the buses and handling the business."

The new model enhanced the bus operator's value proposition. However, barriers to value creation and value capture emerged. The operator had to decide whether to adopt this sustainable-innovation business model. In the following subsections, the traditional and alternative business models as well as the obstacles and barriers that surfaced during this process are discussed.

A. The operator's Traditional Business Model

1. Value Proposition

The bus operator's offering revolved around delivering daily bus services, and planning and operating bus traffic throughout the covered regions. A manager at the operator commented: "We try to deliver transportation that allows people to move quickly and conveniently by bus … to move smoothly [when doing things] like going to work or to entertainment. To meet this challenge, we aim to provide optimized bus solutions."

2. Value Creation

The operator engaged in several activities to help create value. Tendering included all business activities before finalization of the contract and commencement of traffic operations. These activities included looking for new business. In this process, the bus operator searched for potential contracts, and analyzed the calls for tenders received from cities, regions, and transport authorities. This was followed by a process in which the operator selected the most attractive calls for tenders depending on potential margins and risks. Risk assessments were undertaken in this phase and then bus operators were asked to submit quotes for public procurement contracts. At the end of this phase, the operator submitted the tenders and waited to learn which contracts it had won. The final phase was contract execution, which involved traffic planning—a centralized process that included determining bus routes, developing timetables, vehicle plans, and the drivers' daily & monthly schedules. The aim of the traffic planning was to efficiently use resources in the management of daily bus operations.

This phase was followed by traffic management to increase cost efficiencies and, thus, overall profitability. A traffic planner explained the purpose of this activity: "Traffic planning and management ensures that the right number of buses with the right specifications are on the correct route. This is important for reducing parts of routes with empty seats, expanding the use of renewable fuels, and increasing the number of passengers per bus, thereby ensuring the cost efficiency and profitability of contracts." This phase also entailed the procurement of new buses and the utilization of existing buses that met contract standards, as well as the building or renting of depots. As the bus-fleet manager stated: "After winning the contract, we ask for quotes from different manufacturers for several buses to fulfill a 10-to-12-year contract in order to select the solution that best fits us. Which buses to buy and how to utilize them among our different contracts are key. We also rent or build depots with transport authorities to facilitate our operations."

Bus traffic was managed regionally where the operator won contracts. The transport authority controls this process by setting rules and organizing the traffic to ensure certain frequencies of bus service in certain areas. That management was based on a system for different buses using different fuels available at the depots. This ensured a smooth flow and allowed for flexibility-related demands to be met. The traffic-planning activity was highly influenced by certain thresholds set by the transport authority. The bus operations relied on refueling overnight. More specifically, the bus operator purchased or rented buses that were fueled in bus depots overnight. Moreover, the operator usually rented bus depots and garages from the transport authority to facilitate the overnight fueling process.

3. Value Capture

The cost structure for the operator varied according to the geographical location of the traffic operations. When considering cost structure, the driver's salary in northern Europe was the most significant cost element, as noted by a bus-fleet manager: "The drivers' salaries are about 60% of our costs. This is the highest cost we have. On other continents, like Asia, the energy cost is the most significant." Other costs (e.g., fuel, bus procurement) varied. This illustrates the importance of optimization and efficiencies for operators. As most of the contract costs were variable, reducing costs was a matter of strategic importance for operators.

The contracts followed one of two revenue logics: production-based or passenger-based. The operator's marketing-strategy manager explained: "Payment depends on the contract terms. We get paid either in fixed installments if the contract is based on production, or based on the number of passenger tickets validated, called blips, if the contract is based on passenger numbers. Alternatively, there could be a mix of both." The contract-payment methods included the traditional method, which was based on production and bus operators were paid per vehicle/kilometer (common until around 2007), and a new method in which the bus operators were paid per passenger/kilometer. The newer method tied the operator's earnings to the number of passengers validating tickets. Most contracts were a mix of the two logics, and included a revenue model that consisted of a fixed share and a variable share, where the latter depended on the number of tickets sold to passengers boarding the buses. A bus strategist at the transport authority clarified the rationale behind the new logic: "The new contracts create financial motivation for operators to get more passengers … This means more people using public transport. We would like to see more people leaving their cars at home and going by bus."

The transport authority controlled the operator's revenue stream through contract design. When it came to selling tickets under the contract, the operator did not sell tickets to the passenger. Instead, it utilized the transport authority's ticketing system. Thus, the ticket revenues did not go directly to the operator. A business specialist at the operator explained this process: "We do not sell the tickets—the transport authority has the system that manages the ticket sales. We just validate the tickets. We do not see revenue from operations, as it does not pass through our books. The revenue goes directly to the transport authority." Regardless of the contract logic, the tickets were subsidized in public-transport contracts. A manager at the bus operator explained: "Up to 50% of the ticket prices are subsidized by the procuring transport authority through regional taxes."

As stated above, operators had the freedom to run bus operations on their own without public contracts, but solo operations were much more expensive. A business strategist from the transport authority confirmed this point: "Operators may run [solo] operations and discover that they are not profitable, so they came back to contracts to access subsidies. In public transport, bus operation in itself is not self-financing—there are some tax subsidies in all systems. It is basically the same all over Europe. There are very few public-transport lines or operations that can function as fully commercial operations."

The resource-velocity aspect of the bus operator's business model was evident in its utilization of buses. This utilization was monitored with uptime, rotation across regions, and rotation across contracts. A bus-fleet manager explained: "On a fleet level, total demand is constantly changing. Typically, we rotate 10% to 15% of the total fleet for operations with new challenges every year. Variations in demand require us to constantly optimize and monitor needs in different areas. We might need a bigger bus in one place, a smaller bus in another place, and so on, all of which must meet varying frequencies." This flexibility was also important over time and across other regional operations, which meant that the operator needed to utilize buses purchased under the terms of previous contracts. A business manager at the operator explained: "In this low-margin industry, we need to utilize our buses to the full extent, whether through uptime, which is continually keeping our buses running as much as possible, or across contracts or regions."

B. The Operator's Potential Business Model

1. Enhanced Value Proposition

While the bus operator would continue to deliver bus transport, the introduction of the electric hybrid would entail change. The potential offering would be more attractive and environmentally friendly. Therefore, the bus operator would be able to better meet the environmental targets set by the transport authority, especially the targets for noise and emissions. This was due to the fact that the hybrid, inductive-charged buses were quieter and created fewer emissions. The bus-fleet manager explained: "We are excited about the new technologies and are looking forward to deploying them. We see an opportunity with quieter buses. This will enhance our offering to authorities and passengers."

2. Disrupted Value Creation

The application of the new charging technology, contract selection, and traffic planning represented sizeable challenges for management. With regard to contract selection, choosing the right mix of contracts depended on flexible bus provision. Therefore, infrastructure dependence was a significant hurdle in the contract-selection process, as the bus-fleet manager explained: "Selection of the right contracts depends on the turnover of buses within regions as well as the utility of buses from contract to contract. Therefore, if two regions are attractive to operate in but they do not have the same charging infrastructure, we will face a difficult situation."

Traffic planning and management had been built on bus rotation, bus flexibility, and operational efficiencies. Thus, challenges would arise in planning and managing bus operations if the inductive hybrid solution was introduced. The operator would have less flexibility in utilizing the buses during operations. The fleet manager clarified this perspective: "The more flexibility and fewer limitations we have, the more risk we are prepared to take. If we do not have the opportunity to charge buses, then we have substantial infrastructure dependency and less flexibility." In this case, the operator would struggle to meet the traffic targets agreed with the transport authorities.

While the transport authority did not stipulate which technology the operator had to use to run its bus operations, the environmental targets limited the decision space. One of the operator's fleet managers explained: "When the authority tells us the energy efficiency, noise levels, and other criteria we must meet in operations, it leads us to one technology or another. Stopping [to charge] during operations makes us worse off. We do not believe that any charging during operations will work—we need to keep on fueling overnight."

3. Non-Viable Value Capture

The new technology ensured silent, carbon-free bus operations, thereby providing operators with enhanced opportunities to operate in neighborhoods and regions where they were previously restricted due to noise levels. This was viewed as a potential revenue generator. In addition, the charging system would provide scope for operating more lines, which should translate into greater revenue potential. A traffic planner clarified this point: "A quieter, environmentally friendly bus will allow us to operate in areas and at times that we may not be able to operate in today, like near hospitals or during late-night hours."

On the other hand, the new technology would require buses to stop to charge for six to seven minutes at the end of the route during operations, adding costs that would negatively affect the operator's financial performance. A business specialist at the operator explained: "The extra time [needed to charge] during operation means more hours for drivers and higher salaries, or a need for more buses to run the same operations." The bus-fleet manager elaborated on this impact: "Stopping for six to seven minutes to charge reduces our transport efficiency. We estimate a 15% decrease in efficiency, which would lead to an estimated 7% decrease in our net earnings."

The inductive-charging-based operations would also reduce the likelihood of meeting the transport thresholds set by the authorities. Consequently, the operator could be penalized for delays that transcended the thresholds. A traffic planner explained: "The new solutions with new charging infrastructure require our drivers to stop during operations. We need every minute, and this lower uptime translates into penalties because we do not meet the thresholds."

Moreover, negative impacts could follow in the post-contract period because infrastructure-dependent buses could deprive the operator of the flexibility needed to prolong buses' operational lifespans. The typical contract duration was 12 years, and the operator could only use these buses in areas that had the required infrastructure, which could represent significant restrictions. As a fleet operations manager explained: "We usually roll some of our buses from contract to contract. However, a bus that requires a specific infrastructure will hinder this and affect our planning." This dependency would also restrict the operator's ability to alternate the buses according to need—a core part of managing the operations: "If we have to invest in a bus that is heavily infrastructure dependent—for example, if we have several inductive-charging buses in Södertälje—and we run conventional diesel buses in Norrtälje, then there is no opportunity to rotate buses."

While the new business model was sustainable and enhanced the value proposition, the complications in both value creation and value capture made it difficult for the transport operator to consider. In the following section, these results were discussed and analyzed.

VI. Analysis and Discussion

a. Mixed Signals for Value Creation and Value Capture

On the positive side, the discontinuous sustainable innovation manifested in inductive charging seemed to elevate the operator's offering, as it meant quieter, more sustainable, and attractive buses with reduced pollution and greater energy efficiency. More specifically, the lower emissions met the sustainability demands of cities and would help to reduce the negative impact of bus operations. Moreover, the quieter buses would allow the bus operator to operate in areas where noise levels were regulated, such as in the vicinity of hospitals, or at times when noise levels were regulated, such as at night near residential areas.

However, these positive considerations were offset by the value-creation-related complexities facing the operator. The inductive smart-charging bus systems would make the buses heavily dependent on infrastructure. Thus, the traffic-management function would become less flexible, as the operator would be less able to rotate buses between regions and other contracts with different infrastructures. In other words, the operator would be less able to meet performance targets, which would have negative impacts on resource velocity.

Future value capture would be far from certain. It would be enhanced to some extent by the new technology, which would cut energy costs and generate more revenue through the operation of new routes. However, these positive effects would be offset by the disruptions to value creation driven by increased operations time and the reduced ability to rotate the buses. The consequence would be a significant increase in operational costs. Table II summarizes the key components of the bus operator's extant and potential business models, and shows the changes resulting from adoption of the inductive-electric-charging technology for the bus system.

b. The Lock-in of the Operator's Business Model

The transport authority influenced the operator's value capture and value creation through the ticketing system. Moreover, the transport authority tended to exercise tight control of the revenue stream by dictating the payment terms to the operator within the environmental targets, and influencing how the revenue stream was incorporated into the operator's business model.

The operator's freedom to change its business model was restricted by its dependence on the ticket subsidies from the transport authority. The operator was indeed free to undertake operations, make its own bus-solution decisions, and pursue a business model based on contracts with parties other than the transport authority. However, the operator was locked in due to the high transaction costs. More specifically, the subsidies acted as a self-reinforcing mechanism that made the operator's business model viable only with public contracts. Therefore, the subsidy stabilized the extant bus system and hindered further transition to the inductive smart-charging system. This not only confirms the literature suggesting that regulations may hinder innovation [31] but also reveals another reason for such a finding—the lock-in of the business model.

c. Theoretical Implications

To facilitate the socio-technical transition to sustainability, business models often need to be changed. Accordingly, BMI must typically accompany technological innovations to ensure original and sustainable value-creation opportunities [44]. However, making decisions about BMI seems risky due to the uncertainty caused by the complex interrelations between technological developments and BMI [54].

The involvement of the customer is crucial for discontinuous innovation to attain significant breakthroughs [29], as the success and failure of disruptive technologies depend on customers' responses [50]. This is particularly true for sustainable innovations, where success in mainstream markets can be occur when customer preferences and choices are met. This is also the case for niche markets in which innovations for the environment focus on fulfilling customer needs and choices [38].

Sustainability-related innovations probably carry performance disadvantages. However, despite these negative impacts, customers focused on sustainability would likely embrace such innovations. For example, these customers would accept the greater distances and longer trips associated with travelling by train compared to travelling by air in order to reduce emissions. Therefore, a niche exists in which innovations have the chance to prove themselves. Nevertheless, mainstream customers will likely focus more on performance as a general rule, leaving customer evaluations divided.

TABLE II
THE OPERATOR'S CURRENT AND FUTURE BUSINESS MODELS

Operator's Business Model	Value Proposition	Value Creation	Value Capture
Current Business Model	Plan and operate efficient bus traffic Meet environmental targets	Activities *Tendering* Searching for and selecting tenders *Execution* Procurement based on assumption of flexible bus rotation Traffic planning Traffic management Technology Overnight charging People Drivers	Cost structure Driver salaries around 60% of costs Revenue model Subsidized tickets Revenue installments fixed or dependent on the number of passengers Resource velocity High ability to rotate and utilize buses
Future Business Model	(+) Plan and operate an environmentally friendly, attractive bus solution that is energy efficient and allows for potential new routes	(-) Activities (-) *Tendering* Less competitive in tenders due to costs Rigidities in contract selection (-) *Execution* Disrupted traffic planning and management Schedule differences due to charge time; lower operational efficiency; reduced ability to rotate buses Technology Opportunity charging (-) People Increased need for extra drivers	(-/+) Cost structure (-) Costlier buses; increase in man hours; increase in the number of buses needed (+) Lower energy costs (+) Revenue model New routes could generate more revenue (-) Resource velocity Less ability to rotate and utilize buses

In the case studied in this article, the contract seemed to be the threshold, making the sustainability-related discontinuous innovation a win-or-lose scenario rather than a choice among different customer segments. While sustainable technology may have a positive effect on the value proposition, significant disruptions to value creation and value capture are real possibilities. This situation may be related to the business model's dependence on external resources, where the contract's design creates a lock-in situation [39], [47]. In the focal case, the operator was locked into its business model, which thwarted the advance of the discontinuous sustainable innovation and revealed the influence of public-procurement contracts on this process. In contrast to research showing that public-procurement processes prompt and support private actors' attempts to innovate their business models to facilitate sustainability transitions [16], [31], [34], the contract design in the focal case played the opposite role. More specifically, it did not facilitate the future value creation and value capture of the operator's potential business model. This extends the knowledge and understanding of the dynamics of business models in the face of industry transformations [37].

This finding challenges the view that technologies in niche market segments may contest established products by improving upon attributes as requested by principal customers and, thereby, increase the likelihood of entering mainstream markets [7], [12]. This view assumes that change decisions are required on the component level, which may not be true in the context of systemic change. In the case studied here, a complex systemic change is ongoing and that necessitates adjustments on multiple fronts, in contrast to changes related to single products or services that may be desired by individual users or customers. Decision-making in a systemic context is more distributed—it requires changes on multiple levels and needs to be manifested in the contracts.

The business model's lock-in is strongly influenced by public-contract design. Public-transport contracts, like other types of contracts, are designed to reduce risk and uncertainty [14], [26]. However, in the focal case, these contracts acted as a barrier to the discontinuous sustainable technology. The value-creation processes for the discontinuous innovation were restricted because the public-procurement contracts did not indicate a clear value for the sustainable solution. Therefore, public-contract design played a pivotal role in hindering the transition. In the case studied in this article, the desired levels of performance included in the public-contract design were not accommodative of sustainable development.

The operator's business model relied on an outcome-based type of contract in which the performance indicators and payments were tied to the number of passengers using the buses. This efficiency, a value driver also found in the literature [53], was the main value driver in the operator's business model. Other value drivers may include novelty, lock-in [2], complementarity [55], and accountability [49]. Therefore, contracts may need to be approached in a different way to manage the tensions encountered by incumbent actors.

This situation is indicative of a paradox in which the transport authority needed to balance the efficiencies it required for stable transport operations with the novelty needed to change the system into one that was sustainable. Such paradoxes can be managed in four ways: by accepting and constructively using the paradox, by clarifying the level of analysis, by temporally separating the two levels, and by introducing new terms to resolve the paradox [35].

One way to handle the paradox encountered by the operators could be to change the entire perspective on the system's purpose and activities. Therefore, the entire purpose of, and perspective on, the transport system may need to be changed to manage the paradox encountered [30]. This can be done by changing the view on value to include the value of sustainability to a greater degree. This would make the system's purpose not only about transportation but also about limiting negative environmental impacts and making this explicit in the contract. Therefore, a change in the socio-technical system perspective (e.g., transport) would help manage the paradoxical situation induced by the introduction of sustainable discontinuous innovations. It may also help to avoid lock-ins and increase the likelihood that desirable discontinuous sustainability innovations will be adopted.

Another way to handle this paradoxical situation is to extend the system's boundaries, which would allow for new solutions involving other value-creating activities or other actors. At the same time, two propositions could facilitate the adoption of a discontinuous innovation without compromising existing optimizations in the transport system. First, the environment should be a key stakeholder in transport contracts and its importance should be afforded greater weight. Second, the transport system could have its boundaries expanded to include its interactions with the electricity system. By changing the system's boundaries, greater optimization could be achieved.

Finally, contract design can be utilized to visualize the duality and tensions, making it easier to deal with them. For example, variations in contract terms, such as the length of the contract and prices, are likely to increase the value perceived by customers to a much greater degree than fixed agreements on terms [1]. Therefore, adding some variability to the contract may help facilitate the adoption of discontinuous sustainable innovation.

Contract design can be used to generate new views, new perspectives, and new system boundaries. The inclusion of a more comprehensive system description and more comprehensive system opportunities in the contract's design will likely pave the way to new solutions. The problem with the status quo is that there are real environmental challenges in urgent need of attention, but the system is not open to exploring new opportunities in contracts because this situation is new and there is no roadmap. Hence, public-procurement actors are not playing the role they need to play in redesigning the contracts. They can take on an instrumental role in tackling the problems at hand by simply reshaping the contracts. More specifically, these actors need to provide clear parameters for both sustainability and cost targets, and show an openness to adjusting the revenue models in the contracts. Without such an intervention, individual stakeholders may have little chance of advancing discontinuous sustainable innovations.

d. Practical Implications

The operator's business model was locked in due to its dependence on the subsidy element in public-procurement contracts. Free operations are not a financially viable option given the high transaction costs. This lock-in situation filtered out a promising sustainable discontinuous innovation—the inductive smart-charging bus system. This case elevates the pivotal role of the regulatory framework in the adoption of discontinuous innovations for sustainability. It also indicates that regulatory actors may need to take further steps to facilitate innovation and enable the desired systemic change. The authorities could influence the entire system by redesigning public-procurement contracts.

One interesting aspect of this discussion is how customer value is approached in this case in comparison to other types of discontinues or disruptive innovations. In the public-procurement case studied in this article, the systemic innovation had limited opportunities to grow into a niche. Even within the niche, the discontinuous innovation should have been considered superior to the technology used in the traditional business model because the values considered and the boundaries of the system were not questioned. Furthermore, the rules manifested in public procurement formed a much greater barrier to systemic change because the innovation did not have the chance to be tested on a smaller scale due to the lock-in of the business model.

Based on these findings, responsible stakeholders need to avoid situations in which novelty and sustainability are excluded because the contract focuses on efficiencies. To address this issue, approaches to public-procurement contract design need to be explored to ensure that the path to adopting sustainable discontinuous innovation is clear. This highlights the critical role of the actors responsible for contract design and the importance of being aware of the paradoxes at hand when introducing sustainable innovations. In fact, it calls for a readiness to modify the contract's parameters. The actor responsible for contract design may need to embrace and productively incorporate the paradoxes into the contract's design.

The innovation-procurement literature has highlighted such tensions by pinpointing the difficulties that firms face in procurement processes, such as rigid specifications, small contract sizes, and a lack of risk management. This stream of research has concluded that authorities are failing to capture innovation through procurement [46]. Moreover, these complications and ways of dealing with them have been discussed at a high level. Sustainable innovation is usually supported by strategic partnerships in the construction industry, where tensions are handled through systemic conflict resolution [4]. Another perspective on managing the tensions involves encouraging "innovation-friendly" public procurement, and promoting active and collaborative thinking about how best to trade off conflicting policy goals [45]. This approach may not be sufficient because the authority's role in solving these issues is unclear. The results provided in this article take the discussion one step further and shed light on the need for public authorities to translate policy into tangible operational actions with particular reference to managing tensions through contract design.

However, this does not put the ball in the authorities' court or suggest authorities consider implementing a top-down approach to facilitating innovation. Instead, it points to a need to address the systemic nature of the challenges at hand. The transition to electrification entails infrastructure changes—systemic changes that incorporate standardization. Such changes may be driven by the authorities or from the bottom up. However, in the case presented here, a lack of coordination was evident. To put the electrification infrastructure solely in the authorities' hands is problematic because doing so will lead to the favoring of certain types of solutions at the expense of others, with the risk of adopting the wrong technology. At the same time, businesses may find it difficult to solve such strategic infrastructure questions on their own. The question remains unresolved, namely in what way different stakeholders can come to an agreement on systemic changes. This is where procurement-contract design comes into play. Decision-making is needed for a large part of the system but competition for the best technologies needs to be maintained.

A middle way could be to coordinate these efforts by encouraging both businesses and public authorities to co-design public-procurement contracts. If the contracts are designed differently, the innovative solution might not be disregarded as unviable a priori. Therefore, public authorities could enter into dialogues on contract-design parameters with key stakeholders. The aim would be to arrive at a process of systemic discontinuous change if, together, these stakeholders can determine its superior potential for providing clean energy to future transport.

One way to manage the paradox encountered by authorities and operators is to assign an explicit value to sustainability in the contract so that the sustainable technology can improve and thrive to the point where it can overtake the existing technology and deliver the desired sustainable transition. This is an example of an agreement driven by public-procurement contract design. Thereafter, the choices can be reflected in the revenue model's design in the contract. For sustainable bus transport, one suggestion could be to include the type of preferred sustainable bus (e.g., inductive-technology electric buses for certain situations) in the revenue logic. In specific terms, the transport authority could pursue the revenue logic by paying the operator more per passenger when the desired electric bus is utilized.

Another suggestion for managing the paradox may be to expand the transport system to include new boundaries. This could involve, for example, enlarging the system's frontiers to include both transport and electric charging. This would mean that public procurement of charging infrastructure in bus transport could be aligned with the design of transport contracts. More specifically, transport authorities may need to establish the conditions for a harmonized charging infrastructure among traffic regions. In this regard, the operators should be informed of which types of electric buses to procure to maintain their ability to rotate buses around the regions. Furthermore, such infrastructure harmonization would enable operators continue to utilize the buses for future contracts after current contractual periods come to an end.

VII. Conclusions

This article sheds light on the business-model challenge of an incumbent introducing discontinuous sustainable innovation in a public-procurement context. The focus was on the pressure on the incumbent's business model and the attempt to innovate that business model as well as the impact of the adoption of a discontinuous sustainable innovation on the sociotechnical transition to sustainability. The findings illustrate that sustainable innovation may be hindered by the application of rules governing public-procurement contracts rather than customer preferences. Furthermore, in the focal case, the operator was locked into its business model, which acted as a threshold that kept a discontinuous innovation (i.e., a sustainable system) from adoption.

Changes in the perspective on the transport system—especially changes to the contract design—would allow the lock-in situation to be managed and make the success of sustainable innovation more likely. This might be achieved by redesigning the contracts to include either a specific value for sustainability in the revenue installments tied to the number of passengers per sustainable trip, or system boundaries that encompass both transport and electric-charging activities, and by ensuring that the charging infrastructure is harmonized across the regions in which bus operators will submit tenders. This may solve the operators' resource-rotation problem across regions and allow for better utilization of buses in the future. The management of this situation may help maintain a healthy value-creation process based on the operator's business model. In addition, it will enhance the likelihood of adopting and accelerating the transition to electric buses.

In summary, the operationalization of public-procurement policy through contract design may be the key to productive use of resources. This could be an eye opener for the market, the general public, and potential users who may perceive that discontinuous innovation creates value—and probably more so than current offerings. Such recognition might not suffice for the success of a nascent innovation. Without changes to the design of public-procurement contracts, the advancement of such innovations is unlikely.

These results carry implications for the discontinuous-innovation literature and provide practical suggestions for authorities designing public-procurement contracts. In addition, they demonstrate the importance of a fresh approach to contract design that visualizes paradoxical situations and makes their management easier. The management of such paradoxes should increase the likelihood that discontinuous sustainable innovations will thrive.

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