Batteries for Resilience:
Residential vs Community Storage in Canada

Prepared by: Shane Tierney

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Executive Summary

This essay examines decentralized energy resilience in Canada, comparing residential battery storage and community battery storage technologies in the context of extreme weather events and the increasing risks associated with power outages. As climate change increases the frequency and severity of events such as ice storms, wildfires and floods, the reliability of electricity becomes mission-critical for health, safety and critical services. Residential battery storage enhances individual household resilience by providing backup power and integrating with rooftop solar systems. However, diffusion is constrained by high upfront costs, installation complexity, and inequitable access, particularly for renters and low-income groups. Community battery storage, by contrast, provides collective resilience for neighbourhoods and critical facilities, enabling microgrids and visible public benefits, though it faces barriers from high capital requirements and regulatory inertia. This essay leverages two frameworks to delve into the patterns of innovation and diffusion dynamics for both technologies: Pavitt's taxonomy and Rogers' innovation diffusion model. Pavitt's taxonomy provides a lens on innovation, focusing on where knowledge originates, how it is applied, and how firms in various sectors utilize it. It highlights residential batteries as "supplier-dominated" innovations, reliant on external technological advances, while community systems are "scale-intensive," requiring institutional coordination. Rogers' diffusion model further explains adoption patterns, showing faster, broader uptake of community-scale projects due to higher observability, compatibility, and collective benefits. The central argument of this essay is that Canada requires a dual policy strategy: reducing cost and access barriers for households while prioritizing public investment in community storage. An integrated approach, such as this, ensures that decentralized energy storage would deliver equitable and system-wide resilience under intensifying climate risks.

Introduction

This essay investigates the policy issue of decentralized energy resilience in Canada, with a particular focus on the context of extreme weather events and their growing risks. It compares and contrasts two technologies: residential battery storage and community energy storage. Decentralized energy resilience refers to the ability of communities and individuals to sustain an electricity supply independently of the centralized grid. This capability is crucial for Canada, given its vast geography, diverse climate, and increasing vulnerability to extreme weather events (Decentralized Energy Canada, 2023; Natural Resources Canada, 2023). Canada's immense size means many remote, rural, and Indigenous communities are far from major population centers and rely on vulnerable transmission infrastructure (Natural Resources Canada, 2025). The country experiences a wide range of severe weather: winter ice storms, summer heatwaves, wildfires, heavy rains, floods, and hurricanes in the Atlantic and northern regions. Climate change is exacerbating these events, leading to more frequent and prolonged power outages (Hastings-Simon, 2021). Extreme weather can quickly knock out centralized grid power lines, sometimes for days or weeks, endangering public health, food security, and economic stability in affected areas (Decentralized Energy Canada, 2023). This raises an equity concern, as remote,

low-income, and Indigenous communities are disproportionately affected by outages, as help is harder to reach and backup options (such as diesel generators) are often polluting and unreliable (Hastings-Simon, 2021; Natural Resources Canada, 2025). As Canada moves to electrify heating, transportation, and industry (to meet climate targets) and build critical infrastructure for disasters such as hospitals, emergency shelters, water systems, and communications, an uninterrupted power supply becomes mission-critical (Energy Storage Canada, 2025).

Residential battery storage enables individual homes to maintain essential loads during power outages, optimize the use of rooftop solar energy, and participate in energy efficiency programs (Kassaeian, 2025). Community energy storage provides resilience for multiple buildings or entire neighbourhoods, supports local critical facilities, and enables microgrids that can “island” from the primary grid during emergencies, ensuring backup for larger groups (Energy Storage Canada, 2025). These decentralized solutions can operate independently or in conjunction with one another and are becoming increasingly crucial as distributed solar and wind become more prevalent (Decentralized Energy Canada, 2023; Kassaeian, 2025). Canadian federal and provincial policies currently prioritize investments and demonstration projects in energy resilience, particularly in communities that face repeated disruptions. This creates economic and social benefits, as decentralized energy solutions create jobs, foster innovation, support energy sovereignty (especially for Indigenous peoples), and reduce both emissions and reliance on imported fossil fuels (Clean Energy Canada, 2022). Decentralized energy resilience is a top priority for Canada’s climate adaptation and energy future, ensuring people remain safe, connected and empowered – even as extreme weather becomes the new normal (Energy Storage Canada, 2025). To better understand the distinct innovation pathways of residential and community battery storage technologies, this essay draws on Keith Pavitt’s taxonomy (1984) and Everett Rogers’ Diffusion of Innovations model (2003).

Innovation Pathways

The “Pavitt taxonomy” explores why patterns of technical change differ significantly between sectors and builds a framework for understanding innovation by analyzing where knowledge originates, how it is applied, and how firms across diverse industries appropriate it (Pavitt, 1984). The taxonomy identifies four main categories of innovating firms: supplier-dominated, scale-intensive, specialized suppliers, and science-based (Pavitt, 1984). Residential battery storage aligns with Pavitt’s description of a supplier-dominated pattern of innovation, as it relies on technological advances from external entities, such as large battery manufacturers or tech companies. Product innovation essentially drives change – for example, better, more affordable battery units and integration with smart home platforms (Pavitt, 1984; Utterback and Abernathy, 1975). Adoption by users can be fragmented, and benefits accrue at the individual household level. In contrast, community energy storage aligns more with scale-intensive (and even science-based in some contexts) as it often requires complex system integration, process innovation, and is frequently led by utilities, cooperatives, or municipal authorities. Innovation

usually involves adapting solutions to local grid requirements and leveraging research and development (R&D) grants. Community energy storage systems may exhibit “science-based” innovation, particularly when their development depends on the integration of cutting-edge research in materials science or grid management algorithms. Perhaps one of the more notable differences between these two technologies is that the benefits of community energy storage are realized by a wider collective rather than individuals. Appendix A offers a more detailed analysis of how the two technologies differ when assessed against Pavitt’s taxonomy (1984).

Everett Rogers’ Diffusion of Innovations model takes this one step further to explain how new technologies or ideas spread within a social system, categorizing adopters as either innovators, early adopters, early majority, late majority, or laggards, each with distinct adoption patterns (Rogers, 2003). According to Rogers, innovations diffuse at varying rates due to specific characteristics that potential adopters evaluate; relative advantage (perceived improvement over existing solutions), compatibility (fit with user values and needs), complexity (difficulty of adoption), trialability (opportunities to experiment before full commitment), and observability (clarity and visibility of benefits) (Rogers, 2003). Comparing residential battery storage and community energy storage for decentralized energy resilience in Canada, particularly in the context of extreme weather, reveals several key differences. Residential battery storage appeals strongly to innovators and early adopters, often tech-savvy, environmentally conscious homeowners, due to its high relative advantage in autonomy and direct backup (Hyde, 2025). However, adoption is hampered by significant complexity related to installation and technical knowledge, high upfront costs limiting trialability, and low social observability since its benefits are mostly seen privately. Compatibility can also be inhibited in rental or multi-unit dwellings, which curtails broader diffusion (Navius Research, 2020).

By contrast, community energy storage is more compatible with collective governance structures, such as municipalities or rural and Indigenous communities, and tends to diffuse more effectively among the early and late majority (Hyde, 2025; Douglas, 2025). The relative advantage is heightened through shared benefits and community-wide resilience in the face of disruptive weather events (Hyde, 2025). Complexity is less of a barrier, as management is handled professionally, making individual participation more straightforward. Trialability is stronger, with pilot projects or phased rollouts available to showcase the system’s value before full investment (Douglas, 2025; Hyde, 2025). Observability is also higher; benefits are made visible during emergencies and have been known to be shared via local media or municipal communication (Hyde, 2025). Supported by public policy, community energy storage generally diffuses more rapidly and equitably than residential solutions, highlighting its suitability for broad resilience-building in the Canadian context (Hyde, 2025; Navius Research, 2022). For a detailed comparison of how these diffusion dynamics differ between the two technologies, see Appendix B (Rogers, 2003).

To effectively strengthen and influence these patterns of innovation related to decentralized energy resilience in Canada, policymakers must pursue a complementary strategy that influences both the supplier-dominated trajectory of residential storage and the scale-intensive innovation pathway of community storage (Pavitt, 1984). For residential batteries, federal and provincial programs should reduce affordability barriers through targeted rebates, low-interest financing, and inclusion of multi-unit dwellings to avoid reinforcing inequities in resilience (Natural Resources Canada, 2024). At the same time, regulators and utilities should enable the aggregation of residential systems into Virtual Power Plants (VPPs), transforming fragmented private innovations into collective assets that enhance grid stability and climate preparedness. For community storage, governments must address regulatory and financial bottlenecks by establishing clear cost-recovery mechanisms for utilities, providing dedicated grants and R&D funding for municipalities, cooperatives, and Indigenous-led projects, and promoting governance models that secure local ownership and trust (Clean Energy Canada, 2022). Across both pathways, the visibility and trialability of storage technologies should be actively enhanced: pilot projects in climate-vulnerable regions, coupled with transparent outcome reporting and community engagement, can strengthen citizen trust and accelerate uptake beyond innovators and early adopters (Rogers, 2003). Taken together, these measures would not only accelerate diffusion in line with Rogers' framework, but also shift innovation patterns identified by Pavitt toward more socially embedded, system-oriented trajectories, ensuring that decentralized storage delivers equitable and collective resilience benefits under intensifying climate extremes (Pavitt, 1984; Rogers, 2003).

Policy Implications

This essay has compared two innovation trajectories – residential battery storage and community energy storage – as pathways toward decentralized energy resilience in Canada amid intensifying extreme weather events. While both technologies hold potential to mitigate the vulnerabilities of centralized grids, their contrasts in patterns of innovation, diffusion dynamics, and policy needs reflect broader tensions in Canada's national energy strategy: the balance between individual autonomy and collective resilience, and market-driven adoption, and policy-enabled social equity (Pavitt, 1984; Rogers, 2003). A central strength of this analysis lies in applying Pavitt's taxonomy alongside Rogers' diffusion model. Pavitt helps situate residential storage as supplier-dominated, linked to external industrial advances and fragmented household uptake, while portraying community storage as scale-intensive and often science-based, requiring institutional leadership and systemic integration (Pavitt, 1984). Rogers' framework adds further granularity by explaining how adoption spreads socially, highlighting the challenges of cost, compatibility, and observability for residential batteries compared with the greater visibility and collective benefits of community-scale projects (Rogers, 2003). Taken together, these frameworks reveal not only the technological contrasts but also the social and organizational pathways that determine their effectiveness.

Both frameworks, however, have limitations when applied to this context. Pavitt's taxonomy, while useful for mapping structural innovation patterns, was developed in the 1980s within an industrial context and does not fully capture newer dynamics of digital platforms, energy prosumer models, or data-driven virtual power plants. In the case of residential storage, emerging practices such as battery aggregation blur the "supplier-dominated" category since households can contribute to collective grid services, challenging Pavitt's neat analytical separation. Similarly, Rogers' innovation-diffusion framework, while powerful in accounting for user adoption, can understate issues of structural inequity—especially in Canada where affordability gaps, Indigenous energy sovereignty, and geographic inequalities strongly shape adoption outcomes (Hyde, 2025; Navius Research, 2020). These critiques suggest that Canadian policymakers cannot rely solely on technological diffusion logics but must intentionally embed justice and equity-oriented governance into energy storage deployment efforts.

The policy implications derived from this analysis reveal both opportunities and weaknesses. For residential storage, subsidies and grants could accelerate adoption but carry the risk of reinforcing resilience as a luxury good for wealthy early adopters. Unless policies explicitly extend access through affordable housing programs, cooperative purchase models, or support for renters, residential batteries risk producing uneven resilience landscapes (Natural Resources Canada, 2025). Another weakness to consider is that residential adoption alone cannot scale to meet the demands of regional climate disasters. While households may experience localized benefits, they do not replace the need for community-wide, publicly supported initiatives. Community storage, on the other hand, has significant strengths in equitably extending resilience, especially when linked with Indigenous-led projects or municipal co-ops. Its collective nature makes it more compatible with Canada's policy emphasis on reconciliation, regional economic development, and climate justice (Clean Energy Canada, 2022). Yet weaknesses remain: high upfront capital requirements, complex regulatory approval processes, and hesitancy from major utilities to innovate beyond conventional business models (Douglas, 2025). There is also a governance challenge: ensuring that community storage projects remain genuinely community-led, rather than tokenized add-ons within utility-led portfolios (Canadian Renewable Energy Association, 2022). Failure to address these barriers risks slowing diffusion, even in contexts where the collective benefits are most apparent.

Tying these insights back to the central argument—how Canada can harness decentralized storage for energy resilience – the lesson is clear. Resilience cannot be achieved solely through the implementation of technology; it depends on policy-enabled pathways of innovation that balance supplier-driven progress at the residential level with coordinated public investments in community-scale infrastructure (Pavitt, 1984; Rogers, 2003). The integration of bottom-up and top-down innovation trajectories through mechanisms such as virtual power plants, cooperative ownership models, and resilience-focused regulatory frameworks should be a priority for Canadian policymakers (Energy Storage Canada, 2025). Reflecting more broadly, this analysis advances our understanding of decentralized resilience, which encompasses not only technological aspects but also social and political dimensions. Batteries, whether in homes or

communities, are embedded in systems of trust, distribution, and equity. Their capacity to create adaptive energy futures in a climate-constrained Canada hinges not only on cost declines and diffusion rates, but also on governance choices regarding who controls storage, who benefits, and how risks are shared (Clean Energy Canada, 2022; Hyde, 2025). Frameworks like Pavitt and Rogers remain valuable tools for surfacing innovation logics and adoption dynamics at play, but they must be supplemented with justice-oriented, context-specific policy analysis to guide equitable implementation.

Conclusion

In conclusion, decentralized energy storage presents Canada with a unique opportunity to transform climate-induced risk into resilience-building, but achieving this requires a dual-innovation strategy. Residential storage offers autonomy and prosumer empowerment, yet it risks inequity without targeted policy interventions (Canadian Renewable Energy Association, 2022). Community storage aligns more closely with collective resilience goals, but it requires significant coordination and political will to overcome institutional inertia. Navigating these trade-offs will determine whether Canada's energy transition delivers not only cleaner power but also safer and more equitable futures for all communities in the face of a destabilized climate.

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Appendices

Appendix A: Comparison of Patterns of Innovation in Residential Battery Storage and Community Energy Storage (Pavitt, 1984)

Feature	Residential Battery Storage	Community Energy Storage	Key Contrast
Main Innovation Driver	Supplier-dominated, user-led upgrades	Production-intensive/community-led, utility-driven	Residential often "plug and play", community requires integration and customization
Primary Source of Technical Knowledge	Suppliers (e.g., battery manufacturers or third-party installers)	In-house/community energy orgs, utilities, and specialized suppliers	Community solutions often mobilize more local integration knowledge
R&D Structure	Heavily reliant on external innovation; modest in-house adaptation	Mix of in-house & bespoke supplier solutions	Community systems need customization for grid or local needs, spurring unique R&D
Nature of Innovation (Pavitt: product vs. process)	Product innovation dominates (new battery models, easier installation, smart home integration)	Strong process orientation (system-level optimization, smart controls, integration with renewables)	Community innovation is often in design, management and operation rather than the battery itself
Scale and Size of Innovating Firms	Small-to-medium (installers, tech startups), large battery manufacturers	Large utilities/cooperatives, municipal energy providers, and smaller off-grid communities (particularly Indigenous peoples)	Community energy is often led by large, public-facing entities; residential energy is more fragmented
Role of Public Infrastructure	Some public funding (rebates, grid incentives), limited R&D	Greater public sector role (pilot projects, smart grid funding, collaboration with universities)	Community projects benefit more from public R&D, resilience-driven policy
How benefits are captured	Consumer adoption, brand differentiation, service contracts	Collective benefit (grid reliability, shared ownership), utility services, network effects	Community systems leverage scale and risk-pooling, while residential remains individualized
Path of Technological Diversification	Low: batteries as consumer electronics, adaptation for different home types	High: integrated storage with microgrids, shared renewables, demand response, advanced controls	Community models diversify into broader energy services, resilience, and grid management

Appendix B: Comparison of Innovation Diffusion Factors in Residential Battery Storage and Community Energy Storage (Rogers, 2003)

Rogers' Factors	Residential Battery Storage	Community Energy Storage
Relative Advantage	Direct backup for individual homes increases self-sufficiency for homeowners. Strong perceived value in areas with frequent outages and high potential for cost savings.	Community-wide resilience, supporting vulnerable populations and shared facilities. Larger scale cost efficiencies, and can leverage grid services for revenue. Perceived as critical infrastructure, especially in severe events.
Compatibility	Appeals to tech-savvy, eco-minded homeowners. May conflict with rental/condo ownership structures. Aligns with consumer preference for autonomy and societal push for individualism.	Aligns with local/municipal sustainability goals. Strong fit for cooperative or municipal utility models common in Canada. Appeals to communal values and collective action in rural or Indigenous communities.
Complexity	Installation and system sizing can be complex for consumers. Requires high technical literacy and financial commitment. Maintenance is entirely on the homeowner.	Handled by utility or cooperative professionals. Reduced complexity for end users. Complexity borne by institutions, not individuals.
Trialability	High upfront cost limits "trial" options. Some limited pilot/lease programs exist. Users often rely on case studies/word of mouth before adopting.	Trialled at community scale via pilot projects. Can be phased into sub-regions or neighbourhoods. Users can participate without a major individual investment.
Observability	Benefits are most observable during blackouts or billing periods. Hard to see other households' usage. Social visibility is generally low outside environmental circles.	Communities/municipalities can publicly demonstrate results (e.g. rapid recovery after storms). Local media and utility updates can make benefits visible. Model projects can generate more buzz and policy attention.