VIPV as Energy Sources in Disaster Zones

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Executive Summary

Natural disasters continue to severely and unavoidably disrupt communities. These events frequently damage infrastructure, hinder mobility, and isolate neighbourhoods for days or weeks. In such situations, maintaining essential electricity is crucial for safety, communication, and health. This report demonstrates that vehicle-integrated photovoltaics (VIPV) and solar electric vehicles (SEVs) provide a highly robust and adaptable energy source in these scenarios. Their mobility, self-generation capabilities, and independence from fixed infrastructure distinguish them from traditional emergency power systems.

Conventional solutions—such as stationary PV installations, grid-connected storage, and battery electric vehicles (BEVs)—are limited during disasters. They rely on intact infrastructure, stable logistics, and accessible charging sites. When these conditions are compromised, energy supply drops sharply. VIPV and SEVs, however, autonomously generate electricity and can move to areas with better sunlight or higher demand. As highlighted in the report, "their ability to self-generate energy, relocate to irradiance-rich zones, and transport electricity and supplies makes them indispensable in disaster environments."

This study's Monte Carlo simulations, accounting for shading, human behaviour, and unpredictable disaster timing, produce key insights:

Community resilience is achievable through energy sharing. With approximately 13 SEVs per km²—about 1,000 vehicles within a 5 km radius—a community can sustain critical facilities such as medical shelters, cooling systems, and mobile device chargers. On-board PV significantly reduces the number of vehicles needed compared to BEVs.

Even when individuals prioritize their own safety, resilience remains possible. Including realistic self-preservation behaviour, simulations show that 450 or more SEVs within a 5 km radius can power evacuation centres for seven days. In a city like Miyazaki, this corresponds to just 1% SEV penetration, demonstrating that increased adoption of SEVs can ensure dependable disaster response.

VIPV enhances systemic resilience. Unlike fixed PV systems that can be disabled if the host building is damaged, VIPV distributes risk across multiple mobile units. These vehicles can relocate, avoid shading, and maintain energy production even when parked in improvised locations.

Mobility significantly boosts operational reliability. SEVs efficiently collect energy from sunny areas and deliver it to scattered relief points. This mobility enables them to support multiple facilities within a single day, a feat unattainable by stationary systems.

The results clearly demonstrate that VIPV and SEVs are not just alternatives to traditional emergency power solutions—they represent a new class of mobile, self-sufficient energy assets. Their strengths include:

- continuous energy generation even when unattended
- independence from fuel supply chains
- ability to transport both electricity and physical supplies
- compatibility with community-based, voluntary energy-sharing models
- reduced risk of single-point failure compared with fixed installations

The report underscores the critical role of community behaviour. Voluntary sharing of surplus energy significantly boosts resilience, and even modest participation can stabilize energy supply. Simulations clearly demonstrate that when more residents contribute small amounts of energy, the system becomes markedly more robust than relying on a few large contributors.

It is evident that VIPV and SEV technologies are essential components of a distributed, flexible, and socially supported emergency energy network. Their mobility, autonomy, and adaptability make them especially vital in regions vulnerable to earthquakes, typhoons, landslides, and extended outages. As SEV adoption grows, communities will have a scalable and practical tool to maintain essential services during disasters.

In summary, VIPV and SEVs represent a major advancement in building energy-resilient communities. By integrating solar generation, transportation capabilities, and voluntary energy sharing, they provide a realistic and powerful strategy for reducing vulnerability and supporting recovery in the immediate aftermath of natural disasters.

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