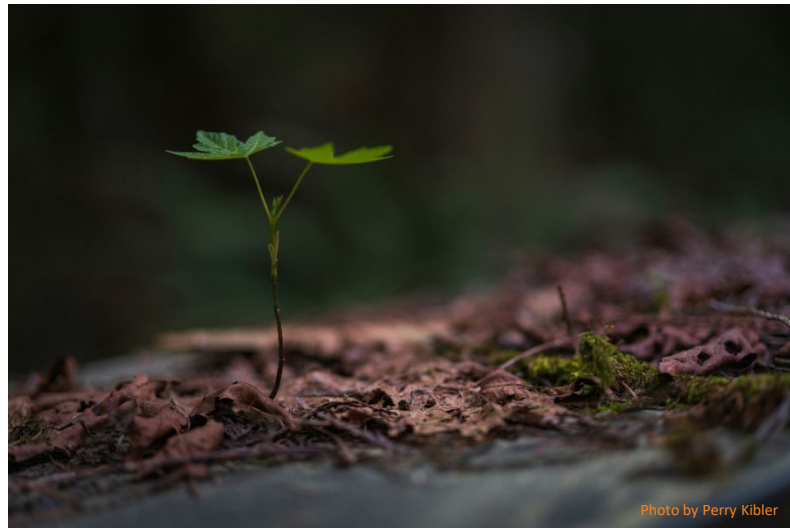




VIPV as Energy Sources in Disaster Zones

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Introduction



Technology Collaboration Programme
by IEA



- Natural disasters continue to severely and unavoidably disrupt communities. These events frequently damage infrastructure, hinder mobility, and isolate neighborhoods for days or weeks.
- 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.
- This report demonstrates that vehicle-integrated photovoltaics (VIPV) / solar electric vehicles (SEVs) provide a highly robust and adaptable energy.

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Task 17 PV & Transport

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VIPV as Energy Sources
in Disaster Zones

2026

Report IEA-PVPS T17-9:2026

<https://iea-pvps.org/wp-content/uploads/2026/05/IEA-PVPS-T17-9-2026-REPORT-VIPV-Disaster-Zones.pdf>

Core Advantages of VIPV / SEVs for Disaster Resilience



1

Continuous Generation

They generate electricity from sunlight even when unattended, reducing the risk of complete battery depletion — unlike battery electric vehicles or diesel generators that stop when fuel runs out.

2

Mobility and Flexibility

They can relocate to areas with better sunlight, avoid building shadows, and deliver energy and physical supplies across multiple facilities within a single day.

3

Grid Independence

They operate entirely off-grid via simple V2L or standalone inverter interfaces. No frequency synchronisation, grid tie, or fuel logistics required.

4

Distributed Risk

Resilience is spread across many mobile units. If one is damaged or shaded, others compensate — unlike a single rooftop PV system that may fail with its host building.

5

Community Sharing

Survey data shows that over 40% of EV owners would voluntarily donate surplus power. Even modest participation can contribute significantly to stabilising supply.

6

Dual-Purpose Asset

Already used for everyday transport; no additional equipment pre-positioned. The concept combines mobility, generation, and storage in one asset with near-zero marginal operating cost.

Effective Use Cases and Limitations



- **Favorable Circumstances**

- Sites where stationary PV or generators are damaged
- Long-duration power outages with partial road access
- Isolated communities awaiting external support
- Mobile, point-to-point energy delivery needs
- Early recovery phase before grid restoration

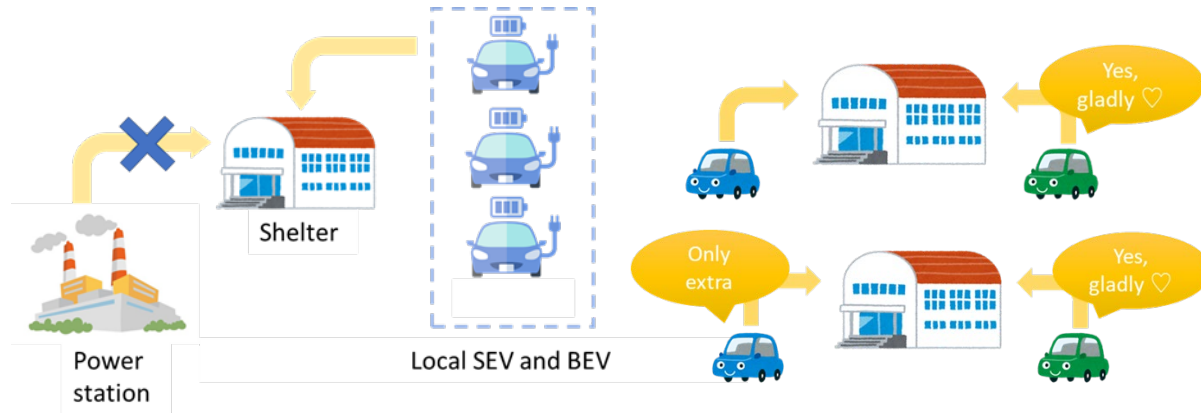
- **Unfavorable Circumstances**

- Severe flooding causing vehicle submersion
- Landslides or collapsed structures blocking road access
- Direct vehicle damage from earthquakes or debris
- Grid-connected V2G or AC synchronization needs

Case Studies and Social Science Dynamics



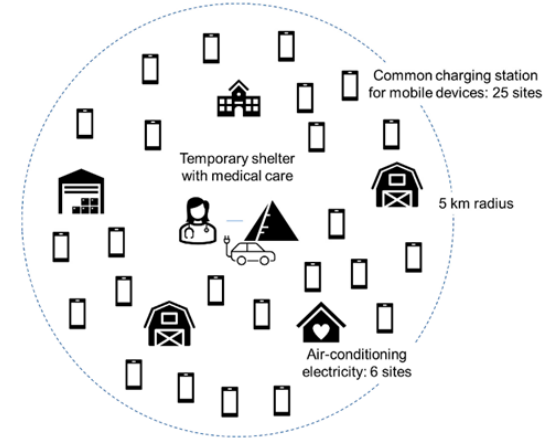
- **Q1:** To what extent can SEVs and BEVs provide energy in isolated disaster zones through surplus battery donations?
- **Q2:** Is it feasible for voluntary contributions from SEVs and BEVs to supply enough electricity for seven days with over 95% probability until critical infrastructure is restored?



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Essential electricity through voluntary contributions from drivers of SEVs and BEVs.

While some drivers are willing to share the electricity required by the community, others prefer to keep it for themselves.



Energy sharing that takes advantage of the mobility of BEVs and SEVs.

Parameters and Assumptions (1)



Parameter	Explanation	Value
Target area	Miyazaki City, residential area	Index No. of METPV: 87376
Number of vehicles equipped with PV	Initial value for Monte Carlo simulation (integer)	200–1,600 vehicles
PV module rated efficiency		22%
PV module covered projected area		1.8 m ²
PV performance ratio	Curvature correction, etc. (temperature correction separately)	90%
Temperature correction coefficient		-0.328%/K
Power management efficiency		93%
MPPT efficiency		95%
Electric fuel economy		8.33 km/kWh
Battery capacity		40 kWh

Parameters and Assumptions (2)

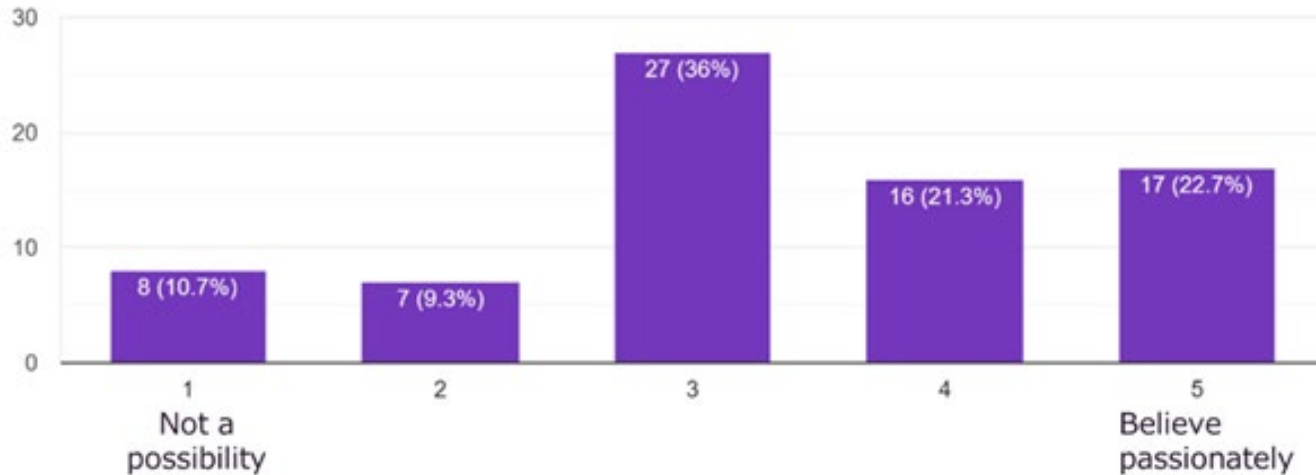


Parameter	Explanation	Value	
Road reflectance	Reflectance to vehicle vertical surface	0.08	
Road reflectance under snow	Reflectance from snow-covered surface to vehicle vertical surface (snow depth > 10 cm)	0.9	
Reflectance of surrounding obstacles	e.g., building walls	0.25	
Number of mobile device charging terminals	Deployed within walking range (1 km)	25	
Required capacity per mobile device charging terminal	24 hours (constant value)	0.2 kW each	
Number of spot air conditioners required		6 units	
Spot air conditioner capacity	24 hours (constant value)	2.2 kW (6 hp)	
Temporary relief center with medical functions		1 location	
Power demand of temporary relief center with medical functions	Varies by time of day	0.36 kW	00:00 – 06:00
		1.61 kW	06:00 – 17:00
		4.47 kW	17:00 – 21:00
		0.36 kW	21:00 – 24:00
Driving distance to public good supply location		5 km	

Probability Modeling Using Monte Carlo Methods



- Focusing on
 - Resilience advantages of SEVs compared to BEVs and other PV-based energy sources
 - Resilience scenario using VIPV using a simple voluntary model
 - Resilience scenario using VIPV with selfish power hoarding
 - Guidelines considering regional VIPV energy generation



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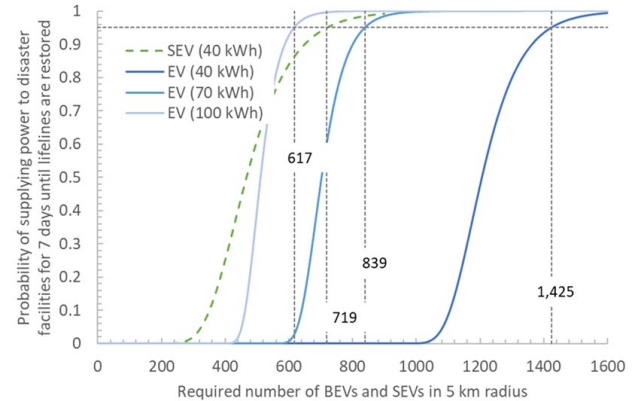
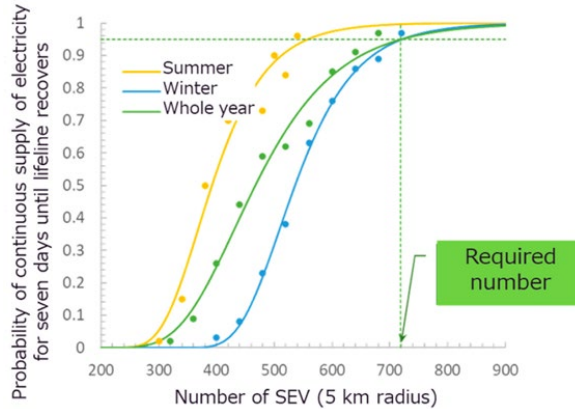
Q: If you own an EV, would you be willing to supply electricity to shelters without power?

A: In our study, 40% responded affirmatively to the idea of voluntary donation.

Monte Carlo Modelling: Key Findings



- Simulations ($\approx 10,000$ trials per scenario) accounted for shading environments, human behavior, seasonal solar variation, and disaster timing to assess demand–supply balance across a 7-day recovery period.
- Community resilience is achievable through energy sharing. With approximately 13 SEVs per km^2 —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. SEV significantly reduces the number of vehicles needed compared to BEVs.



Probability illustrating the likelihood of maintaining success for 7 days.

Seasonal variation

SEV compared to BEV

Monte Carlo Modelling: Key Findings



- Even when individuals prioritize their own safety, resilience remains possible. Including realistic self-preservation behavior, simulations show that 450 or more SEVs within a 5 km radius can power evacuation centers 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.

Scenario	SEVs required (5 km radius)	Key condition
Simple voluntary model	~1,000 SEVs (13/km ²)	5% of owners donate when SoC > 90%
Selfish power-hoarding model	450+ SEVs	Owners keep personal reserve while donating surplus
BEV (40 kWh) comparison	~1,425 BEVs	No onboard generation; dependent on pre-disaster charge
SEV vs BEV (same battery size)	SEV needs ~half the number of vehicles	Onboard PV continuously recharges the battery

Emergency Energy Demand: What VIPV Can Power



- A commercial VIPV system that converts standard trucks and trailers into mobile solar power units by installing high-efficiency PV modules on roof and side surfaces, e.g. SolarOnTop, developed by Dutch startup IM Efficiency, can generate 40-45 kWh/day (typical spring/fall performance).
- With two units, all the following basic emergency power needs can be easily met:

Application	Daily need (kWh/day)	Description
Mobile phone charging (2,000 devices)	13–14	Critical for public communication
LED lighting (evacuation centre)	8–12	500–1,000 m ² facility, 12–16 hrs/day
Medical equipment refrigeration	8–12	Vaccines, oxygen concentrators, diagnostics
Water pumping & purification	10–15	Portable RO purification system for 500–1,000 people
Emergency communications hub	5–10	Satellite terminals, radio, Wi-Fi

Research and Policy Priorities



Incentive design for voluntary energy sharing

Develop reward mechanisms that encourage SEV owners to donate surplus power to community shelters without coercion. Simulations show that many small donors outperform reliance on a few large contributors, and reward mechanisms encourage broader, sustained participation.



Worst-week solar radiation planning

Resilience planning must use worst-week irradiance data rather than annual averages to avoid significant overestimation of available energy.



Regional VIPV energy guidelines

PV power generation relies on solar radiation, which can differ significantly from recorded data and experiences notable regional and seasonal variations. Therefore, shading factor tables and energy yield formulas (by climate zone and urban density) must be established so as to simplify local resilience assessments.



Integration with disaster logistics

Coordinate VIPV deployment with government traffic management and transport of supplies to ensure energy actually reaches scattered relief facilities. It is imperative that response measures and a chain of command are clarified in the event of a disaster

Next Stage



The first report – Quantitative approach
far from a traditional resilience report



More case studies



HDV resilience under control may be
more acceptable than voluntary
contribution by SEVs

More balanced and for wider readers



VIPV interaction
Microgrid, Portable PV system, PV-CS

Thank you

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