

**The power plant of the future  
isn't a smokestack. It's all  
around your home.**

**- Futurist Jim Carroll**





# The Decentralization Dividend

## A Five-Year Forecast of the Evolving Global Energy Network

- The global energy grid is undergoing its most profound transformation in a century
- Evolving from centralized, one-way delivery to multi-directional, intelligent networks
- The next five years represent a critical inflection point in this transition
- Enormous business opportunities extend beyond hardware into sophisticated services





# From Centralized Power to Decentralized Network

## The Old Paradigm

- Large, centralized power stations
- One-way electricity flow
- Passive consumers
- Limited resilience

## The New Reality

- Distributed, renewable generation
- Multi-directional energy flow
- Active "prosumers"
- Enhanced resilience and control

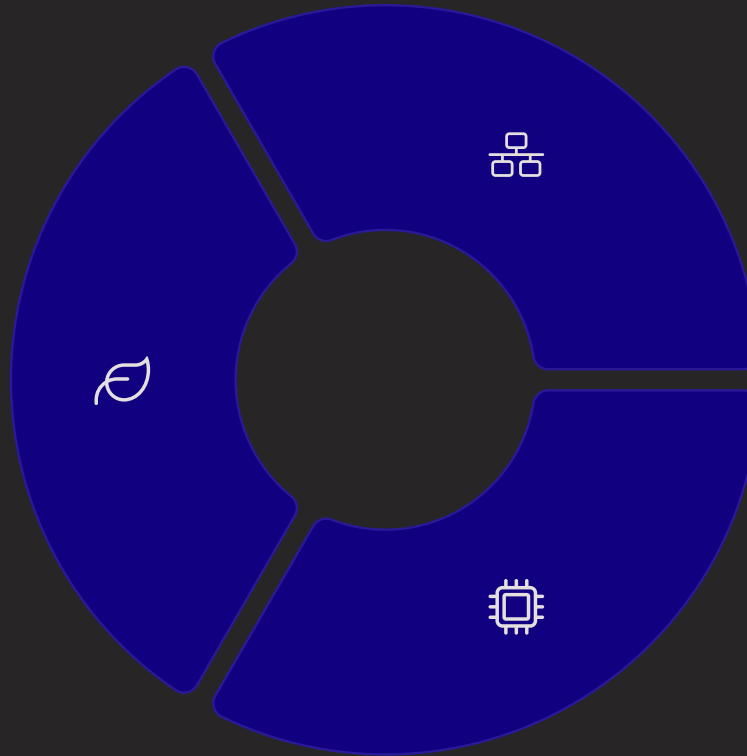
This evolution from a one-way delivery monologue to a multi-directional energy dialogue is the defining feature of the 21st-century grid.

# The Three Ds Driving Energy Transformation

## Decarbonization

Climate mandates driving shift from fossil fuels to renewables

Paris Agreement and national targets creating powerful market signals



## Decentralization

Energy generated, stored, and managed closer to consumption

Emergence of "prosumers" who both produce and consume energy

## Digitalization

Smart meters, IoT sensors, and advanced software enabling responsive grid

Two-way flow of electricity and data creating an "aware" network

# Global Drivers with Regional Variations



## Europe

Leading with "Fit for 55" package and REPowerEU plan

Renewable Energy Directive explicitly empowers prosumers

Germany and Denmark pioneering community energy models



## North America

Driven by Investment Tax Credit and Inflation Reduction Act

Market-focused approach with corporate PPAs

Virtual Power Plants emerging in California and Texas



## Asia-Pacific

Fastest growth region with soaring energy demand

China dominates solar PV manufacturing and deployment

Decentralized systems electrifying remote communities



# The Core Components of Decentralization



## Distributed Energy Resources (DERs)

Solar PV, battery storage, smart thermostats, and EV chargers at the grid edge



## Microgrids

Local energy grids that can disconnect and operate autonomously in "island mode"



## Intelligent Management

Software platforms that optimize energy flows and enable participation in markets



# The Regulatory Architecture

## Crafting the Market for Decentralization

### Strategic Mandate

Paris Agreement, EU Green Deal, US Inflation Reduction Act setting long-term direction

### Grid Edge Regulations

Streamlined interconnection, net metering, enabling third-party ownership

### Financial Incentives

Tax credits, grants, rebates, and subsidized loans reducing upfront costs

This multi-layered approach is systematically creating a de-risked and attractive market for decentralized energy investment.

# Navigating the Headwinds



## Remaining Barriers to Widespread Adoption

- Regulatory and institutional inertia slowing implementation
- High upfront capital costs limiting equitable access
- Grid infrastructure becoming the "weak link" in the transition
- Technical workforce shortages constraining deployment

The IEA warns that electricity grids risk becoming the bottleneck in the energy transition, with modernization investment lagging far behind renewable generation.





# The Prosumer Toolkit

## The Integrated Home Energy System



### Solar Photovoltaics

High-efficiency monocrystalline panels serving as the primary on-site generation technology



### Battery Storage

Stores excess solar energy, provides backup power, and enables economic optimization



### Energy Management

Software that orchestrates energy flows to maximize economic benefit and convenience

# The Community Nucleus

## Microgrid Architecture

A microgrid is a self-contained energy system serving a defined local area that can operate both while connected to the main utility grid and in "island mode" when the main grid fails.

Microgrids combine multiple DERs at different scales:

- Distributed rooftop solar
- Shared community battery
- Controllable loads

They provide superior local reliability and resilience, especially in regions prone to extreme weather events.







# The Digital Overlay

## The Virtual Power Plant (VPP) Ecosystem

A VPP is a cloud-based digital platform that aggregates thousands of individual, geographically dispersed DERs and orchestrates them to act as a single, large-scale, dispatchable power plant.

### Market Functions

Demand response, peak capacity, and ancillary services for grid stability

### Value Creation

Direct revenue streams for DER owners while providing essential grid services



# The Foundational Layer

## Essential Grid Modernization



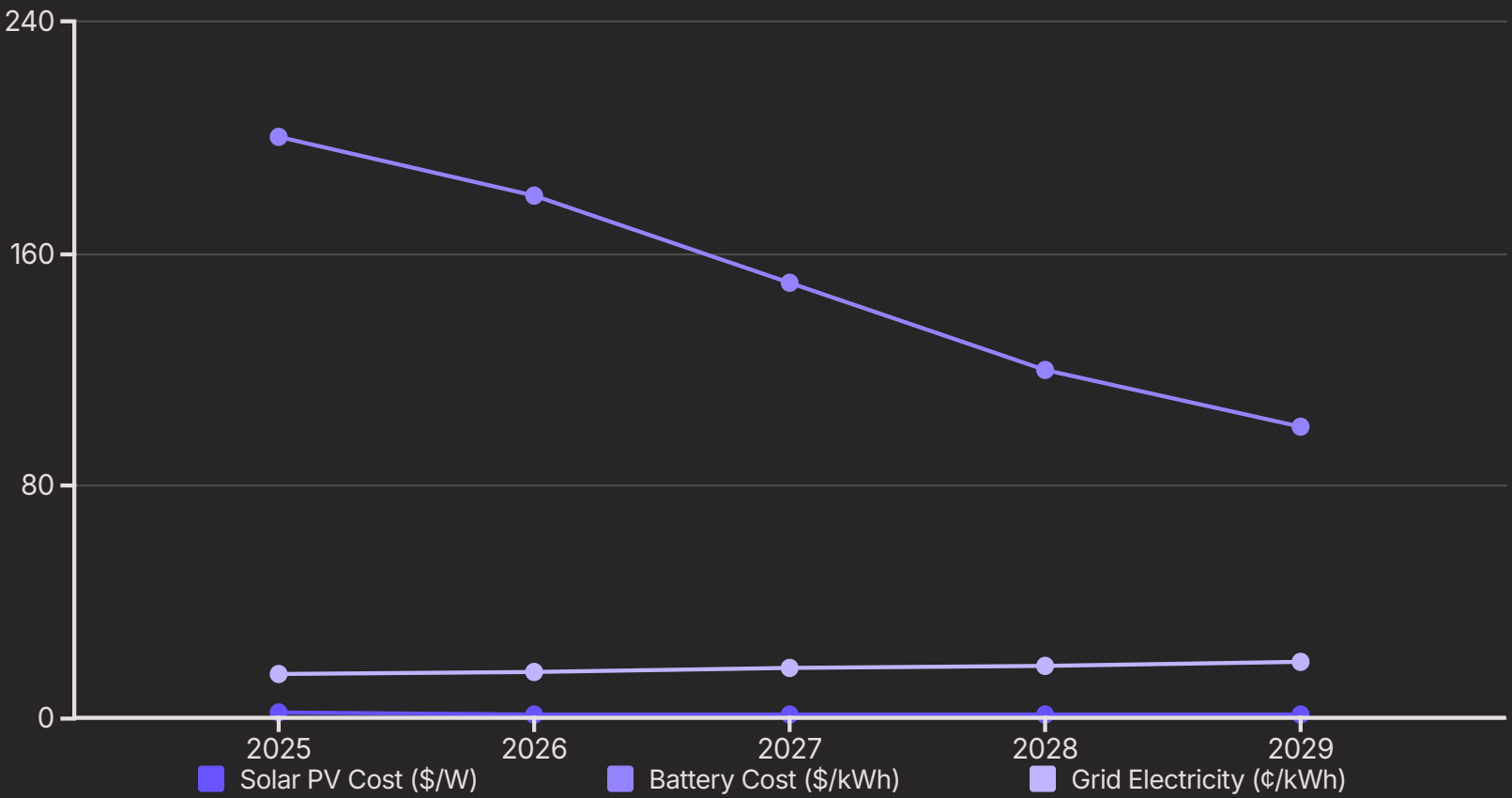
The IEA warns that global investment in electricity grids has remained stagnant for a decade, even as investment in renewables has soared.

Modernizing the grid requires:

- Smart meters for real-time consumption data
- Advanced sensors on distribution lines
- Robust communications networks

Investment in grids needs to nearly double by 2030 to over USD 600 billion per year to meet climate targets.

# The Economic Calculus



The "spread" between the cost of self-generated power and grid power is set to widen dramatically over the next five years, creating a powerful financial incentive for mass-market adoption.



# The Psychology of Adoption

## What Motivates the Consumer?

### Primary Motivators

1. Cost reduction and financial control
2. Reliability and backup power
3. Environmental concern

### Key Barriers

1. High upfront cost
2. Perceived complexity
3. Trust and provider choice

The market is transitioning from "early adopters" to the "early majority"—a much larger, more pragmatic group primarily motivated by practical benefits and averse to complexity.



# Market Momentum

## \$2T

### Global Renewable Market

Projected size by 2029, growing at 8.7% CAGR from \$1.3T in 2024

## \$2.2T

### Clean Energy Investment

Forecast for 2025, double the investment in fossil fuels

## \$444B

### Corporate PPA Market

Projected size by 2033, expanding from \$28.3B in 2023

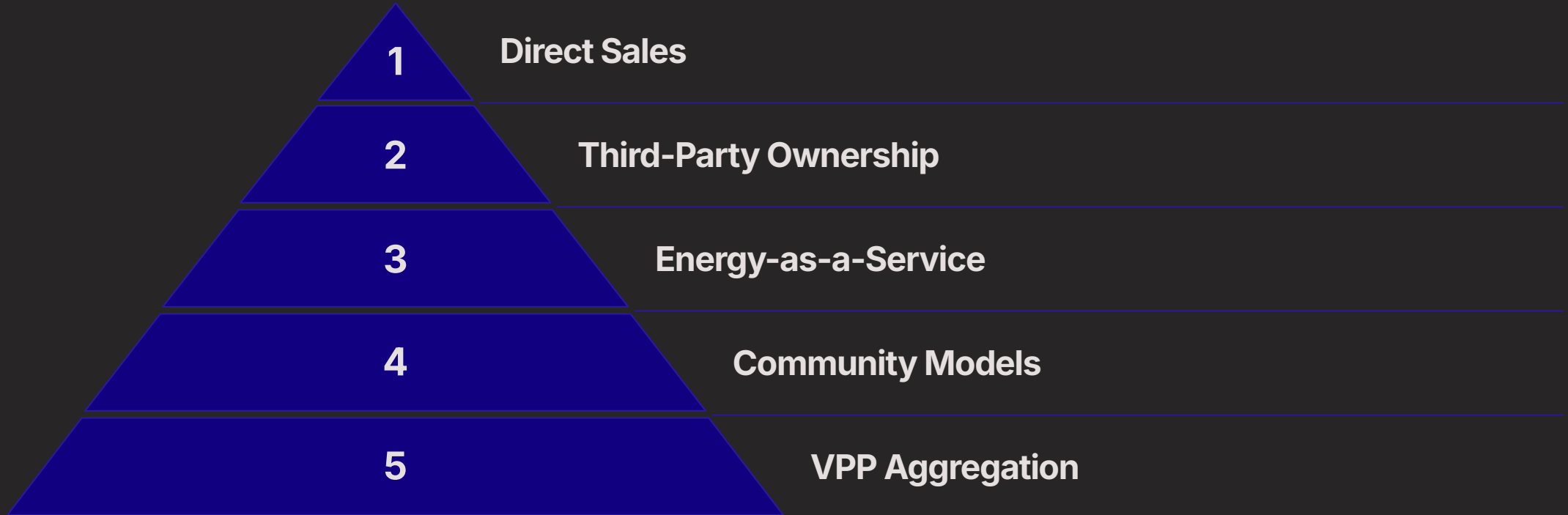
## 18.8%

### DERMS Growth

CAGR for Distributed Energy Resource Management Systems through 2029



# The Emerging Business Ecosystem



A key theme is the move away from one-time hardware sales toward recurring revenue models based on services and performance.



# Direct-to-Consumer Models

## Direct Purchase

- Customer owns system outright
- Maximizes long-term ROI
- Requires access to capital
- Business opportunity in hardware margin

## Third-Party Ownership

- Solar leases and Power Purchase Agreements
- Zero upfront cost for customer
- Predictable long-term revenue for provider
- Requires supportive regulations





# The Subscription Economy

## Energy-as-a-Service (EaaS)

In an EaaS model, the provider takes full responsibility for designing, financing, installing, owning, and operating a suite of DERs tailored to the customer's needs.



### Customer Value

Predictable fee for guaranteed outcomes (savings, resilience, carbon reduction)



### Target Market

Commercial, institutional, and industrial clients seeking to transform CapEx into OpEx

# Power in Numbers

## Community and Cooperative Energy Models

### Community Solar

Centralized solar project with multiple subscribers

Individuals receive bill credits proportional to their subscription

Democratizes access for renters and those with unsuitable roofs

Popular in parts of the U.S.

### Investment Co-operatives

Community-owned renewable projects

Local investors receive steady financial returns

Keeps financial benefits within the community

Pioneered in European countries like Germany and Denmark



# The Aggregation Economy

## The VPP Operator Business Model



Leading VPP operators include CPower, Enel, and AutoGrid in North America.



# The Evolving Utility

## A Strategic Crossroads



### Platform Orchestrator (DSO)

Act as neutral market facilitator for DERs connecting to the distribution grid



### Integrated Energy Services

Compete directly by offering DERs and energy services to customers



### Traditional "Poles and Wires"

Focus on core infrastructure business while accommodating third-party DERs





# The Innovators and Disruptors

## The Global Startup Landscape

### Hardware Innovators

Urban Electric Power (next-gen batteries)

NEXT Energy Technologies (advanced solar cells)

Focus on fundamental technology improvements

### Software Platforms

Virtual Peaker (VPP software)

EnergyHub (DERMS platforms)

Rhizome (grid analytics)

### Project Developers

LevelTen Energy (PPA procurement)

Sunnova's Project Hestia (low-income focus)

New financing and development models

# Five-Year Forecast (2025-2029)

## 2025-2026: Acceleration Phase

Major policy packages drive investment wave  
Regulators focus on streamlining grid connections  
Third-party ownership models experience rapid growth

1

2

## 2027-2028: Scaling Phase

Battery costs reach tipping point for mainstream adoption  
Customer base shifts from early adopters to early majority  
EaaS becomes competitive offering for businesses of all sizes

3

## 2029: Integration Phase

DERs fully incorporated into grid planning  
DSO model proven in pioneering regions  
Cybersecurity emerges as major concern and market



# Strategic Imperatives for Stakeholders

## For Investors

- Focus on scalable customer acquisition engines
- Target software companies developing orchestration platforms
- Consider EaaS providers as infrastructure investments

## For Entrepreneurs

- Build "simplification-as-a-service" platforms
- Develop specialized O&M services
- Address growing DER cybersecurity market

## For Incumbent Utilities

- "Wait and see" is no longer tenable
- Choose between competing directly or facilitating the market
- Form partnerships with new market entrants

## For Policymakers

- Refine market rules to optimize DER value
- Standardize interconnection procedures
- Address looming skilled labor shortage



# Learn More

[energy.jimcarroll.com](https://energy.jimcarroll.com)

Discover comprehensive insights on the global energy transition and electrification trends at Jim Carroll's dedicated resource hub. His keynotes provide expert analysis, market forecasts, and investment opportunities in renewable energy. His material is regularly updated to help you navigate.

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3. Moore's law defines innovation velocity

