Rack-Level DC Power Architecture Using Cluster Mesh Turbines for AI Data Centers

Infinity Turbine LLC

[TEL] +1-608-238-6001 (Chicago

[Email] greg@infinityturbine.com

https://www.infinityturbine.com/rack-level-dc-power-architecture-using-cluster-mesh-co2-turbine-generation-by-infinity-turbine.html

A hyperscale data center architecture using Cluster Mesh turbine generators to deliver 48 V or higher DC power directly to server racks, eliminating traditional AC PSUs and improving efficiency, density, and resilience.

This webpage QR code

PDF Version of the webpage (maximum 10 pages)

Hyperscaler Rack-Level DC Power Generation Using Supercritical CO2 with Busbar and Buffer

Replace centralized AC power chains with rack-level DC generation: Cluster Mesh turbines paired with DC busbars and buffer storage redefine efficiency, resilience, and density for next-generation AI data centers.

1. Introduction: The Shift to Rack-Level Power Domains
Modern AI data centers are rapidly transitioning from centralized AC distribution toward rack-level power architectures. The traditional model—medium voltage AC stepped down through UPS systems and converted again at the server—introduces multiple inefficiencies, thermal losses, and infrastructure complexity.
A new approach leverages Cluster Mesh turbine generators integrated at the rack level to produce direct current (DC) power, distributed via busbars at 48 VDC or higher voltage DC architectures. This eliminates the need for per-server AC power supply units (PSUs) and significantly simplifies the electrical chain.

2. Cluster Mesh Rack-DC Architecture Overview
The proposed architecture places power generation adjacent to the rack (sidecar or rear-mounted module) rather than embedding it within compute slots.
Core Components
1. Cluster Mesh Turbine Module (25–100 kW per rack)
• Supercritical CO2 or ORC-based microturbine array
• Outputs regulated DC power
• Modular (1–4 × 25 kW units)
2. DC Bus (48 V or High Voltage DC)
• Rack-level busbar distribution
• Designed for high current (48 V) or reduced current (higher voltage DC)
3. Energy Buffer Layer
• Lithium-titanate battery or supercapacitor
• Handles transient GPU loads and ride-through
• Stabilizes turbine output
4. Compute Sleds (DC Input Only)
• No AC PSU
• Local DC-DC conversion (point-of-load regulators)
5. Cooling Module (Dedicated Blade or Sidecar)
• Liquid cooling CDU
• Removes heat from GPUs and turbine electronics
• Optionally integrates waste heat recovery loop

3. Electrical Architecture Flow
Conventional Path (Legacy)
MV AC → Transformer → UPS → PDU → Rack PSU → Server VRMs
Cluster Mesh Rack-DC Path
Thermal Input → Cluster Mesh Turbine → DC Regulation → DC Bus → Buffer → Compute Nodes (POL only)

4. Voltage Strategy: 48 V vs Higher Voltage DC
48 VDC (Baseline)
- Proven (OCP Open Rack standard)

Copyright 9/8/2026 Infinity Turbine LLC

Copyright 9/8/2026 Infinity Turbine LLC

100 MW Data Center Savings Using Cluster Mesh Rack-DC Power Architecture

Quantified savings for a 100 MW AI data center using Cluster Mesh rack-level DC power architecture. Reduce conversion losses, eliminate server PSUs, and achieve multi-megawatt efficiency gains.

A 100 MW AI data center can eliminate multiple megawatts of continuous losses by replacing traditional AC power chains with Cluster Mesh rack-level DC architecture—delivering millions in annual savings and redefining hyperscale efficiency.

1. Executive Summary
As AI data centers scale beyond 100 MW, traditional AC power architectures are becoming increasingly inefficient due to layered power conversions and distributed losses. A Cluster Mesh Rack-DC architecture, using sidecar turbine modules with 48 V or higher-voltage DC distribution and buffer storage, fundamentally changes the power delivery model.
By eliminating the per-server AC PSU stage and reducing total conversion steps, this architecture delivers 2% to 5.6% total electrical savings, equivalent to 2.2 MW to 5.6 MW of continuous power reduction in a 100 MW facility.

2. Baseline: Conventional Power Architecture
Typical hyperscale data centers use:
MV AC → Transformer → UPS → PDU → Rack PSU → Server VRMs
This architecture introduces losses at every stage:
• Transformer and switchgear losses
• UPS double-conversion losses
• Distribution losses
• Server-level AC-DC PSU inefficiencies
These losses compound at scale and directly increase both electrical consumption and cooling demand.

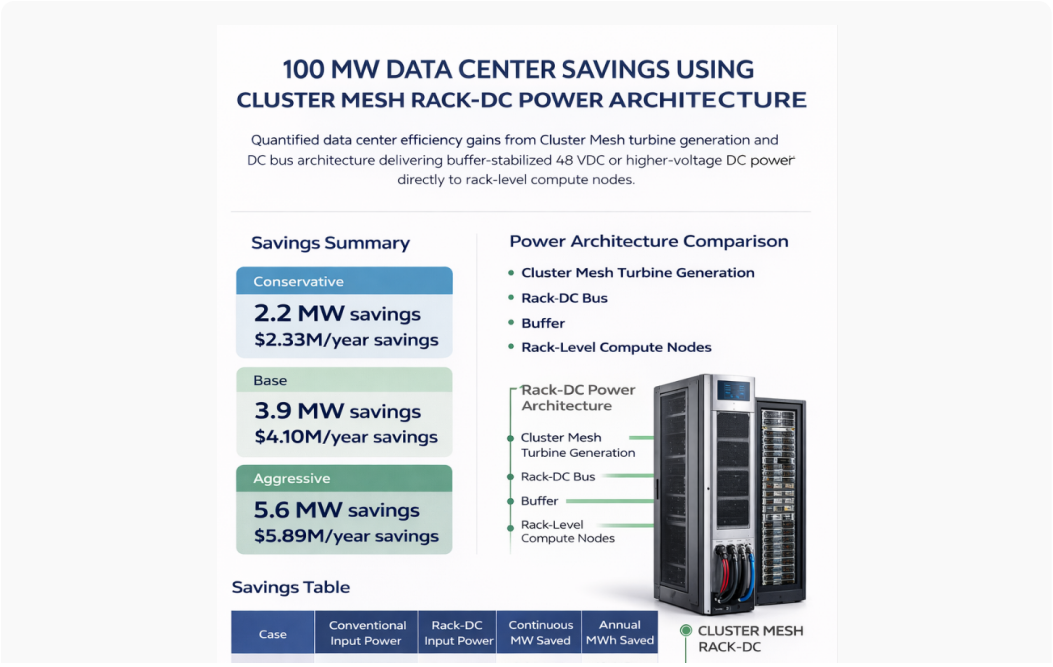
3. Proposed Architecture: Cluster Mesh Rack-DC
The Cluster Mesh approach shifts power generation and conversion to the rack level:
Thermal Input → Cluster Mesh Turbine → DC Regulation → Rack DC Bus → Buffer → Compute Nodes (POL only)
Key Characteristics
• Sidecar-mounted 25–100 kW turbine modules per rack
• 48 VDC or higher-voltage DC busbar distribution
• Elimination of server PSUs
• Integrated energy buffer (battery or supercapacitor)
• Co-designed power + cooling architecture

4. 100 MW Data Center Model Assumptions
To quantify savings, the following efficiency ranges are used:

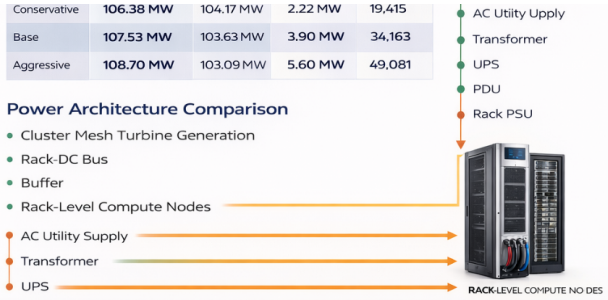
Architecture	Efficiency Range
Conventional AC Chain	92% – 94%
Cluster Mesh Rack-DC	96% – 97%

All results below assume 100 MW delivered to IT load.

5. Quantified Power Savings



Conservative	**106.38 MW**	104.17 MW	2.22 MW	19,415
Base	**107.53 MW**	103.63 MW	3.90 MW	34,163
Aggressive	**108.70 MW**	103.09 MW	5.60 MW	49,081



Copyright 9/8/2026 Infinity Turbine LLC

100 MW DATA CENTER SAVINGS USING CLUSTER MESH RACK-DC POWER ARCHITECTURE

Quantified data center efficiency gains from Cluster Mesh turbine generation and DC bus architecture delivering buffer-stabilized 48 VDC or higher-voltage DC power directly to rack-level compute nodes.

Savings Summary

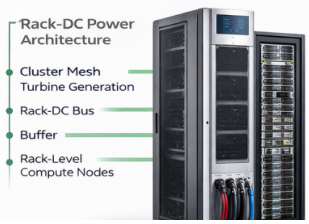
Conservative
2.2 MW savings
$2.33M/year savings

Base
3.9 MW savings
$4.10M/year savings

Aggressive
5.6 MW savings
$5.89M/year savings

Power Architecture Comparison

- **Cluster Mesh Turbine Generation**
- **Rack-DC Bus**
- **Buffer**
- **Rack-Level Compute Nodes**



Savings Table

Case	Conventional Input Power	Rack-DC Input Power	Continuous MW Saved	Annual MWh Saved
Conservative	**106.38 MW**	104.17 MW	2.22 MW	19,415
Base	**107.53 MW**	103.63 MW	**3.90 MW**	34,163
Aggressive	**108.70 MW**	103.09 MW	**5.60 MW**	49,081

Power Architecture Comparison

- Cluster Mesh Turbine Generation
- Rack-DC Bus
- Buffer
- Rack-Level Compute Nodes
- AC Utility Supply
- Transformer
- UPS

Copyright 9/8/2026 Infinity Turbine LLC

100 MW summary table

Case	Conventional Input MW	Rack-DC Input MW	Continuous MW Saved	Annual MWh Saved	Savings at $0.12/kWh
Conservative	106.38	104.17	2.22	19,415	$2.33M

Base	107.53	103.63	3.90	34,163	$4.10M
Aggressive	108.70	103.09	5.60	49,081	$5.89M

Copyright 9/8/2026 Infinity Turbine LLC

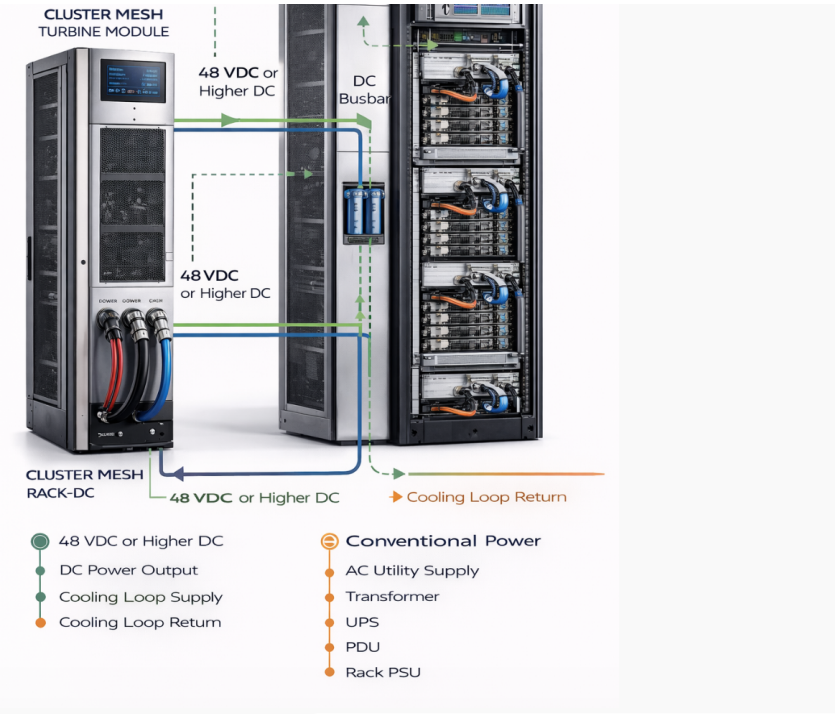
At typical commercial electricity rates:

Case	Energy Saved (MWh/year)	$0.08/kWh	$0.12/kWh	$0.20/kWh

Conservative	19,415	$1.55M	$2.33M	$3.88M
Base	34,163	$2.73M	$4.10M	$6.83M
Aggressive	49,081	$3.93M	$5.89M	$9.82M

Copyright 9/8/2026 Infinity Turbine LLC

Copyright 9/8/2026 Infinity Turbine LLC



Copyright 9/8/2026 Infinity Turbine LLC