Efficient Power Distribution

277Vac distribution w/o centralized UPS
95% High Efficiency solution
Battery Cabinet as Distributed Backup Energy Unit

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Traditional power distribution

- Utility to Substation: 120kV → 35-12.5kV
- Site transformers: High/Medium Voltage, 2-3% loss
- AC to DC Rectifier: 540VDC
- Batteries: 540VDC → 480V
- DC to AC Inverter: 540VDC
- UPS: 8-12% loss
- Site Distribution: 2-4% loss
- PDU: 480V
- Server PS: 208V
- 12, 5, 3.3 VDC
- Mobile VRM: 3.3 – 1.0 VDC
- Component: Server, 23-40% loss
Optimized power distribution

- **Utility** to **Substation** 120kV → 35-12.5kV
  - **Site transformers** with High / Medium Voltage and 2-3% loss
  - **Battery** with 0% loss and 8-12% loss
  - **Site Distribution** 1-2% loss and 2-4% loss
  - **Server** 14% loss and 23-40% loss
- **Server PS** to **Mobo VRM** 12 VDC → 3.3 – 1.0 VDC to **Component**
Power Backup Scheme

LE G E N D

Online Power
Backup Power

48VDC Battery Cabinet

277VAC

4x12V Batt
4x12V Batt
4x12V Batt
4x12V Batt

48VDC Battery Charger

48VDC standby

N+1 battery

*Server PS

277VAC

Back up converter 48VDC-12V DC

AC to DC 277VAC - 12VDC

12VDC

MOBO
A modern ‘std power distribution’ vs. ‘Open Compute power’

- Transformer: 97%
- AC UPS: 96%
- PDU: 99%
- IT PS: 85% (η = 78.3%), 90% (η = 83%)
- Open Compute PS: 98.2% (η = 91.7%), 96.8%, 95%
- Battery Rack: 99.5%
DC offline UPS – CapEx saving

Traditional UPS & PDU
$2.00 / W

Optimized UPS & no PDUs
$0.10 - $0.35 / W
Dual-input Open Compute 450W PSU - high level block diagram
Dual-input Open Compute 450W PSU - functional block diagram

- **Input Stage**
- **PFC Stage**
- **DC-DC Stage**
- **Logic Stage**
- **Backup Converter**

Connections:
- 277Vac to Input Stage
- 54Vdc (from Battery Cabinet) to Logic Stage
- 12Vdc from DC-DC Stage

Symbols:
- BULK
- INRUSH
OCP 450w PSU form factor
OCP 450W Power Supply

• Custom 1.5U tall, high volume
• 48VDC backup equipped
• HE AC–DC switching
• 180 – 290 VAC wide input range
• 94.5% efficient
• Low iTHD < 5%
• High Power Factor > 0.99
• Board-to-board mating connector
• Pin and plunger mounting
• Single low-speed cooling FAN
• Random restart after AC outage avoids Genset potential start-up issues
OCP PSU Backup Sequence

Backup Sequence in case of AC loss event lasting less than 6 seconds:

- **AC LOSS**
  - Main Converter: ON
  - Backup Converter: OFF
  - AC LOSS detected (max delay)
  - AC LOW condition included (Vin < 170Vac)

- **AC = ON**
  - Both converters ON at the same time

- **AC = OFF (< 6 sec)**
  - ON
  - OFF

- **AC_BULK OK**
  - 1
  - 0
  - When (in time) will actually go "LOW", is load dependent

- **t**
  - 0 sec
  - 5mS ≤ T1 ≤ 10mS
  - 5mS ≤ T2 ≤ 105mS
  - > 6 sec

- **T1 (max) = 105mS**: there is 100mS time-out for backup engagement after a detected 'AC LOSS' signal, regardless the load.

The start of a Backup Sequence is primarily driven by 'AC LOSS' signal, in conjunction with 'AC_BULK OK' signal.
AC Random Restart (real measurement)
OCP 450W PS Efficiency targets

• Efficiency target (277Vac input):
  Eff. > 95% (50% to 90% of full load)

• Efficiency also exceeds Climate Savers Computing Initiative “PLATINUM” std.

• Power Quality target (277Vac input):
  PF > 0.95 (> 20% of full load)
  THD < 10% (> 20% of full load)

• High PF & low iTHD reduce losses in transformers, noise in power lines, Neutral Current, GenSet start-up problems, etc.
Server level with custom power strips (top view)
OCP Server chassis
OCP Server chassis
OCP Server chassis

450W power supply

drive cage

fans

AMD / Intel motherboards
OCP Battery Cabinet

• Custom DC offline UPS
• 56kW or 75kW, 277VAC 3-phase input
• Six 48VDC 175A outputs
• 45 sec backup time at full load
• 95% efficient Rectifiers for batteries charging and online power for IT Switches
• 20 sealed VRLA high-discharge batteries
• Battery monitoring system (impedance measurement), Vbatt, Ibatt, temperature
• Two 50A 48VDC aux outputs for IT Switches
OCP DC Offline Backup Energy Unit: Battery Cabinet

- Six 250A DC Breakers (for Main Load)
- Two extra 50A DC Breakers (for IT Secondary Load)
- Rectifier Shelf with its own Controller (may be included in the same shelf)
- Optional 2nd Controller
- 56.6KW Battery Cabinet
- 1800A BUS-BAR

Battery Strings:
- Battery String 1
- Battery String 2
- Battery String 3
- Battery String 4
- Battery String 5

Included in each Battery String are:
- One DC FUSE Quick Disconnect
- One Hall effect sensor

Dimensions:
- Width = 24"
- Depth = 36"
- Height = 84"
OCP 56.6KW Battery Cabinet
Open Compute Project – Whole System
High-Current DC bus-bar enhancement

![Diagram showing high-current DC bus-bar enhancement]
Open Compute Project – Whole System
Rack level cabling

- Front access only
- Network cable management harness
- 30 outlets 277VAC (custom AC power strip)
- 30 outlets 48VDC (custom AC power strip)
- Custom 277VAC and 48VDC power cords
AC & DC Power Strips in the triplet rack column
Triplet Rack

- Triplet RACK design – 90 servers
- Fast deployment, rolling casters with levelers
- Welded 2” square-tube frame, powder coat finish
- Hot/cold isle containment
- Six 1U auxiliary shelves (IT Switches)
- High IT Switch port utilization
Open Compute 700-SH power supply

- 700W output
- High power DC backup mode
- Output Current sharing capable
- Same form factor as Open Compute 450W power supply
- Updated output connector, back compatible
- Efficiency exceeding 95% on broad load range
New Windmill System with OCP 700W-SH PSU
New Windmill System with OCP 700W-SH PSU not installed
New Windmill System with OCP 700W-SH PSU installed