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Analysis of Data Center Electrical Architectures Supporting OCP

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Schneider Electric
Critical questions arise about what is upstream of the rack…

- If I adopt Open Compute, what does my power architecture look like?
- Can I get N+1, 2N, 2(N+1) (i.e. tier 3) redundancy levels like I have today?
- How do I support traditional and Open Compute IT loads in the same data center?

Answering these questions will broaden adoption…
Important to understand the cost trade-offs

Analysis Assumptions

- Analyzed capital cost (material cost only)
- Compared traditional and Open Compute specific architectures
- From MV switchgear down to (and including) IT power supply
- Key assumptions:
  - OCP PSU/BBU/shelf costs based on design by Schneider Electric
  - Traditional server PSU costs & sizing based on various IT vendors/suppliers
  - Models based on 9.6MW data center, 10 kW/rack
  - Costs normalized to €/Watt

Based on the content of white paper 228, Analysis of Data Center Architectures Supporting Open Compute Project (OCP)
Traditional vs. OCP-based designs

2.52€/watt

<table>
<thead>
<tr>
<th>Traditional 2N</th>
<th>Open Compute Specific 1N</th>
<th>Open Compute Specific 2N</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.52€/watt</td>
<td>1.46€/watt</td>
<td>1.85€/watt</td>
</tr>
</tbody>
</table>

We think most will want to maintain 2N (Tier 3) redundancy

“Tiers” in a nutshell

Tier 1: Single power path to IT load; single points of failure

Tier 3: Dual (redundant) power paths to IT load, concurrently maintainable
Traditional 2N power architecture today…

Typical 2N design for traditional IT loads

- 2N power paths from utility to load, Tier 3(ish)
- Adds complexities ("Belts & suspenders"):
  - Load bank
  - Ties
  - Additional UPS output breakers
- Concurrently maintainable
Open Compute Specific 1N architecture

An example of a cost-reduced architecture to support OCP loads

- Aligns with the simplicity and cost-reduction mindset of OCP
- Open Compute servers with one PSU path
- Single path to the IT load
  - with rack-based battery backup
  - no centralized UPS
- Minimal breaker count
Traditional 2N vs. Open Compute Specific 1N

42% capex savings…
but where do these savings come from?
Traditional 2N vs. Open Compute Specific 1N

31% savings is from redundancy differences…
Traditional 2N vs. Open Compute Specific 1N

- Traditional 2N: 2.52
- Redundancy: 0.79
- Rack system: 0.03
- Open Compute Specific 1N: 1.46

1% cost adder for rack system
Traditional 2N vs. Open Compute Specific 1N

8% savings from eliminating upstream UPS…
Traditional 2N vs. Open Compute Specific 1N

UPS
Rack system
Redundancy
Power supplies
Batteries

€ / watt

Traditional 2N: 2.52
Redundancy: 0.79
Rack system: 0.03
UPS: 0.20
Batteries: 0.14
Open Compute Specific 1N: 1.46

6% cost adder for Li-ion batteries
Traditional 2N vs. Open Compute Specific 1N

<table>
<thead>
<tr>
<th>Component</th>
<th>Traditional 2N</th>
<th>Open Compute Specific 1N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power supplies</td>
<td>0.24 €/watt</td>
<td>0.20 €/watt</td>
</tr>
<tr>
<td>Batteries</td>
<td>0.14 €/watt</td>
<td></td>
</tr>
<tr>
<td>UPS</td>
<td>0.20 €/watt</td>
<td></td>
</tr>
<tr>
<td>Rack system</td>
<td>0.03 €/watt</td>
<td></td>
</tr>
<tr>
<td>Redundancy</td>
<td>0.79 €/watt</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>2.52 €/watt</td>
<td>1.46 €/watt</td>
</tr>
</tbody>
</table>

10% savings from power supplies
2N (or tier 3) is still important to many data centers

- Redundancy
- Concurrent maintainability
Open Compute Specific 2N architecture

2N simple design to support OCP IT loads

Compared to traditional 2N, this architecture....

- reduces complexity by eliminating unnecessary cross-ties, additional breakers
- saves cost with N+1 batteries and PSUs
- trusts the redundant server power supplies
Cost difference of Traditional 2N vs. Open Compute Specific 2N

26% capex savings…
Cost difference of Traditional 2N vs. Open Compute Specific 2N

A simplified 2N design costs 2.16 €/watt… (that accounts for more than half of the 26% savings)
Cost difference of Traditional 2N vs. Open Compute Specific 2N

Rack, UPS, battery, and PSU differences represent the remaining…

PSUs are still N+1 but dual fed
Cost difference of Traditional 2N vs. Open Compute Specific 2N

- **Traditional 2N**: €2.52
- **Architecture simplification**: €0.36
- **Rack system**: €0.01
- **UPS**: €0.20
- **Batteries**: €0.14
- **Power supplies**: €0.11
- **Open Compute Specific 2N**: €1.98

Additional 0.13 € / watt for 2N OCP PSUs over N+1
What if I have a mix of Open Compute and traditional IT loads?
A design that accommodates both types of loads

- Traditional 2N: 2.52 €
- Open Compute Specific 1N: 1.46 €
- Open Compute Specific 2N: 1.85 €
- Simplified 2N: 1.91 €

Premium for traditional power supplies (PSUs) depends on mix of loads. Assumptions:
- 0.42 € traditional PSU cost per watt of IT load
Example of a Simplified 2N design that accommodates both types of loads

- Flexible architecture that allows for mix of traditional IT loads and OCP loads
- UPS is upstream to support both traditional and OCP loads
- To minimize cost, one power path with UPS, one without
- OCP loads have dual PSUs without BBUs, but this could be an N+1 PSU with dual input.
Freely available resources to help with planning decisions

Reference Designs
• Designs to support OCP (Ref Design 101.0, 56MW)
• One-line diagrams, bill of materials, layout drawings
• www.schneider-electric.com/datacenterdesigns

TradeOff Tools
• OCP vs. traditional cost comparison tool
• Li-ion vs. VRLA TCO tool
• tools.apc.com

White Papers
• WP228, Analysis of Data Center Architectures Supporting OCP Designs
• WP229, Battery Technology for Data Centers: VRLA vs. Li-Ion
• whitepapers.apc.com
Key takeaways...

• Today’s traditional 2N architectures have opportunity for simplification and cost reduction

• Centralized rack based PSUs provide significant cost savings

• Simplified 2N represents a small premium and gives flexibility for mixed-loads
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# PSU Assumptions

<table>
<thead>
<tr>
<th>Variable</th>
<th>Traditional data center</th>
<th>OCP-style data center</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSU price per PSU watt</td>
<td>0.07€</td>
<td>0.08€</td>
</tr>
<tr>
<td>PSU shelf price per PSU watt</td>
<td>Not applicable</td>
<td>0.05€</td>
</tr>
<tr>
<td>PSU redundancy factor</td>
<td>2</td>
<td>1.17 (5+1) for 1N OCP and mixed-loads 2 for 2N OCP</td>
</tr>
<tr>
<td>PSU oversizing factor</td>
<td>3</td>
<td>1.2</td>
</tr>
<tr>
<td>PSU price per IT load watt</td>
<td>0.07 x 2 x 3 = 0.42€</td>
<td>(0.08+0.05) x 1.17 x 1.2 = 0.18€ (0.08+0.05) x 2 x 1.2 = 0.31€</td>
</tr>
</tbody>
</table>
PSU cost is a highly sensitive variable...

Our baseline assumption for traditional PSUs:

\[
\begin{align*}
0.071 \text{€ per PSU watt} \times 2 \text{ PSUs per server} \times 3 \text{ PSU oversizing} &= 0.42 \text{€ per IT load watt}
\end{align*}
\]

Sensitivity analysis:

We varied the PSU oversizing down to 2 and up to 4.5, or 0.28 € to 0.63 € / IT load watt
## Battery Assumptions

<table>
<thead>
<tr>
<th>Variable</th>
<th>Traditional data center</th>
<th>OCP-style data center</th>
</tr>
</thead>
<tbody>
<tr>
<td>Battery type</td>
<td>VRLA</td>
<td>Lithium-ion</td>
</tr>
<tr>
<td>Battery run time</td>
<td>5 minutes</td>
<td>4 minutes</td>
</tr>
<tr>
<td>Battery placement</td>
<td>Centralized UPS</td>
<td>Rack-based</td>
</tr>
<tr>
<td>Battery cost per watt</td>
<td>0.06€ for 1N UPS</td>
<td>0.17€</td>
</tr>
<tr>
<td></td>
<td>0.11€ for 2N UPS</td>
<td></td>
</tr>
<tr>
<td>Battery shelf watt</td>
<td>Not applicable</td>
<td>0.03€</td>
</tr>
<tr>
<td>Operating temperature</td>
<td>25°C</td>
<td>25°C</td>
</tr>
</tbody>
</table>
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