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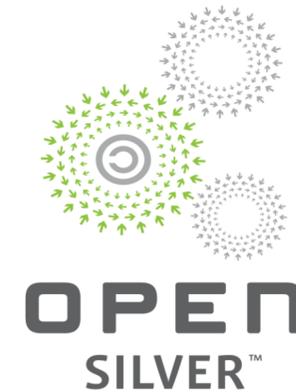
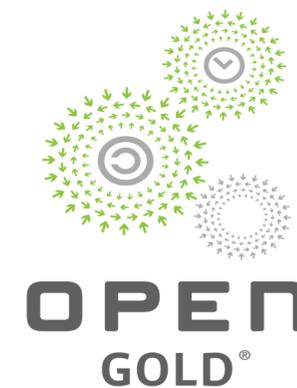
OCP
SUMMIT

Finite Element Modeling of the 12V power distribution within Open Rack Standard 2.0. Analysis of the losses and temperature rise.

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Content

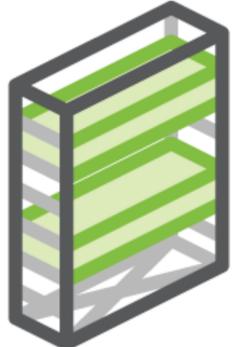
Rack configurations

FEM simulation model

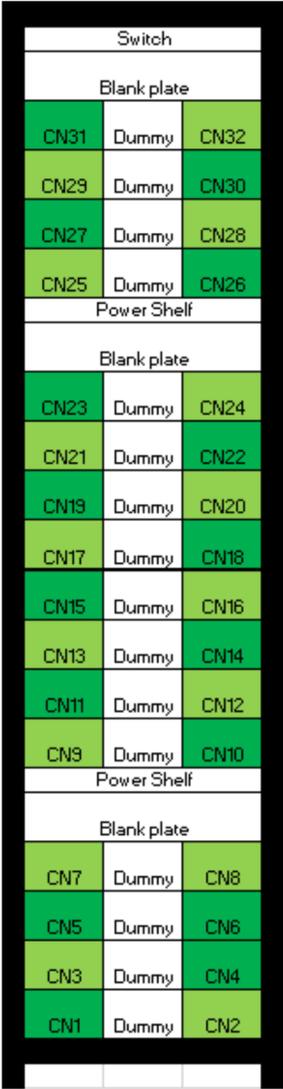
FEM simulation results

Conclusion

Config. 1 - Typical ORv2 Rack layout



RACK & POWER



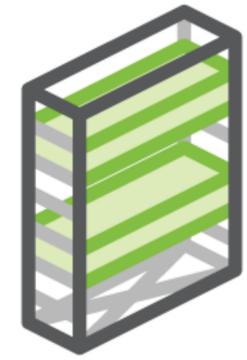
Amount	Part Number	min weight	max weight	idle power (W)	max power (W)
2	Bel Power Solutions SPSPFE3-08 Power Shelf	NA	300	NA	18000 (5+1)
12	Bel Power Solutions PFE3000-12-069RA	NA	NA	NA	3000
1	19" switch kit	0	0	NA	NA
3	2OU blank plate	NA	NA	NA	NA
16	Dummy node	NA	NA	NA	NA
16	Cubby for 3 server	224	224		
16	Wiwynn SV7220G3 (330W)	110,4	116,8	1728	5280
16	Wiwynn SV7220G3 (330W)	110,4	116,8	1728	5280
	Total	716,8	729,6	3486	10560

- Typical 330W max server, as per datasheet
- 3+3 3kW PSU = 9kW limit per zone
- Switch not taking into account



Tested Configurations

Config. 2 - Rack filled with Vendor max spec



Switch		
CN55	CN56	CN57
CN52	CN53	CN54
CN49	CN50	CN51
CN46	CN47	CN48
CN43	CN44	CN45
Power Shelf		
CN40	CN41	CN42
CN37	CN38	CN39
CN34	CN35	CN36
CN31	CN32	CN33
CN28	CN29	CN30
CN25	CN26	CN27
CN22	CN23	CN24
CN19	CN20	CN21
CN16	CN17	CN18
Power Shelf		
CN13	CN14	CN15
CN10	CN11	CN12
CN7	CN8	CN9
CN4	CN5	CN6
CN1	CN2	CN3

Amount	Part Number	min weight	max weight	idle power (W)	max power (W)
2	Bel Power Solutions SPSPFE3-08 Power Shelf	NA	300	NA	18000 (5+1)
12	Bel Power Solutions PFE3600-12-069RA	NA	NA	NA	3600
1	19" switch kit	0	0	NA	NA
19	Cubby for 3 server	266	266		
30	Wiwynn SV7220G3 (330W)	207	219	3240	9900
27	Wiwynn SV7220G3 (330W)	186,3	197,1	2916	8910
	Total	959,3	982,1	6186	18810

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- Typical 330W max server, as per datasheet
- 3+3 3.6kW PSU = 10.8kW limit per zone
- Switch not taking into account

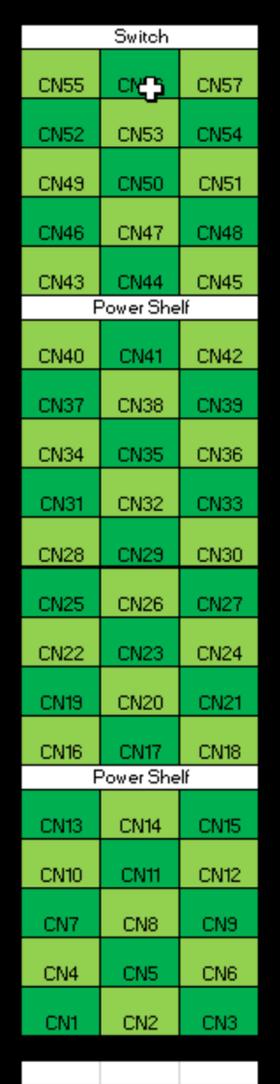


Case Studies

Config. 3 - Tioga Pass spec max



RACK & POWER



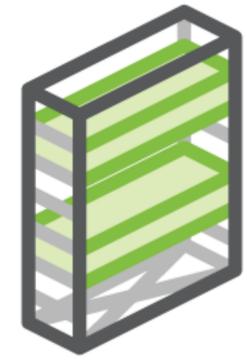
Amount	Part Number	min weight	max weight	idle power (W)	max power (W)
2	Bel Power Solutions SPSPFE3-08 Power Shelf	NA	300	NA	18000 (5+1)
12	Bel Power Solutions PFE3600-12-069RA	NA	NA	NA	3000
1	19" switch kit	0	0	NA	NA
19	Cubby for 3 server	266	266		
30	SV7220G3 (max TDP 165W)	207	219	3240	12300
27	SV7220G3 (max TDP 165W)	186,3	197,1	2916	11700
	Total	959,3	982,1	6186	23370

- 410W max server, as per Tioga Pass spec
- 5+1 3kW PSU = 14.4kW limit per zone
- Switch not taking into account

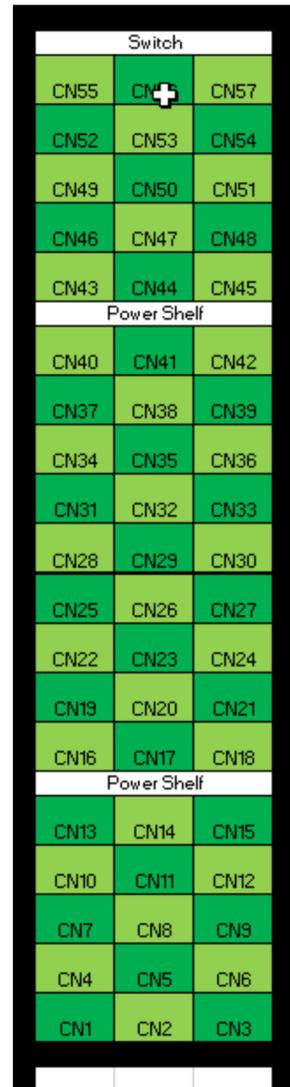


Case Studies

Config 4 - Tioga Pass with one GPU



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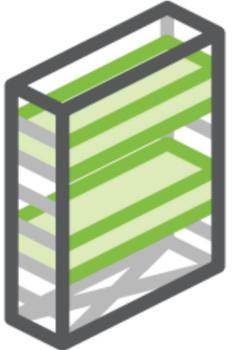
Amount	Part Number	min weight	max weight	idle power (W)	max power (W)
2	Bel Power Solutions SPSPFE3-08 Power Shelf	NA	300	NA	18000 (5+1)
12	Bel Power Solutions PFE3000-12-069RA	NA	NA	NA	3000
1	19" switch kit	0	0	NA	NA
19	Cubby for 3 server	266	266		
30	SV7220G3 (single CPU&GPU)	207	219	3240	11850
27	SV7220G3 (single CPU&GPU)	186,3	197,1	2916	10665
	Total	959,3	982,1	6186	22515

- 395W max server, as per Tioga Pass spec
- 165W CPU and 150W GPU
- 5+1 3kW PSU = 14.4kW limit per zone
- Switch not taking into account



Case Studies

Config. 5 - Highest TDP Available



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Switch		
CN55	CN56	CN57
CN52	CN53	CN54
CN49	CN50	CN51
CN46	CN47	CN48
CN43	CN44	CN45
Power Shelf		
CN40	CN41	CN42
CN37	CN38	CN39
CN34	CN35	CN36
CN31	CN32	CN33
CN28	CN29	CN30
CN25	CN26	CN27
CN22	CN23	CN24
CN19	CN20	CN21
CN16	CN17	CN18
Power Shelf		
CN13	CN14	CN15
CN10	CN11	CN12
CN7	CN8	CN9
CN4	CN5	CN6
CN1	CN2	CN3

Amount	Part Number	min weight	max weight	idle power (W)	max power (W)
2	Bel Power Solutions SPSPFE3-08 Power Shelf	NA	300	NA	18000 (5+1)
12	Bel Power Solutions PFE3600-12-069RA	NA	NA	NA	3600
1	19" switch kit	0	0	NA	NA
19	Cubby for 3 server	266	266		
30	SV7220G3 (TDP 205W)	207	219	3240	14700
27	SV7220G3 (TDP 205W)	186,3	197,1	2916	13230
	total	959,3	982,1	6186	27930

- 490W max server, in theory
- 5+1 3.6kW PSU = 18kW limit per zone
- Switch not taking into account



Case Studies

Simulation Setup



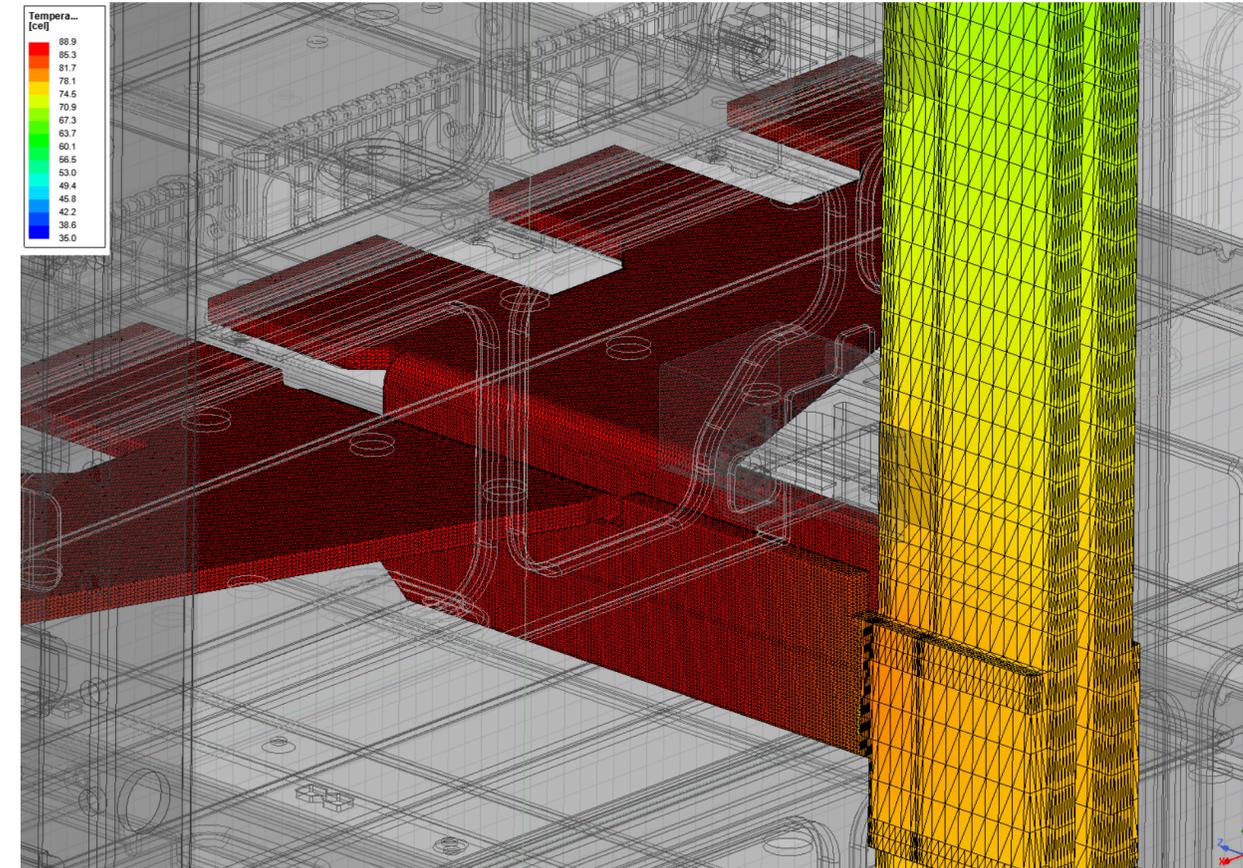
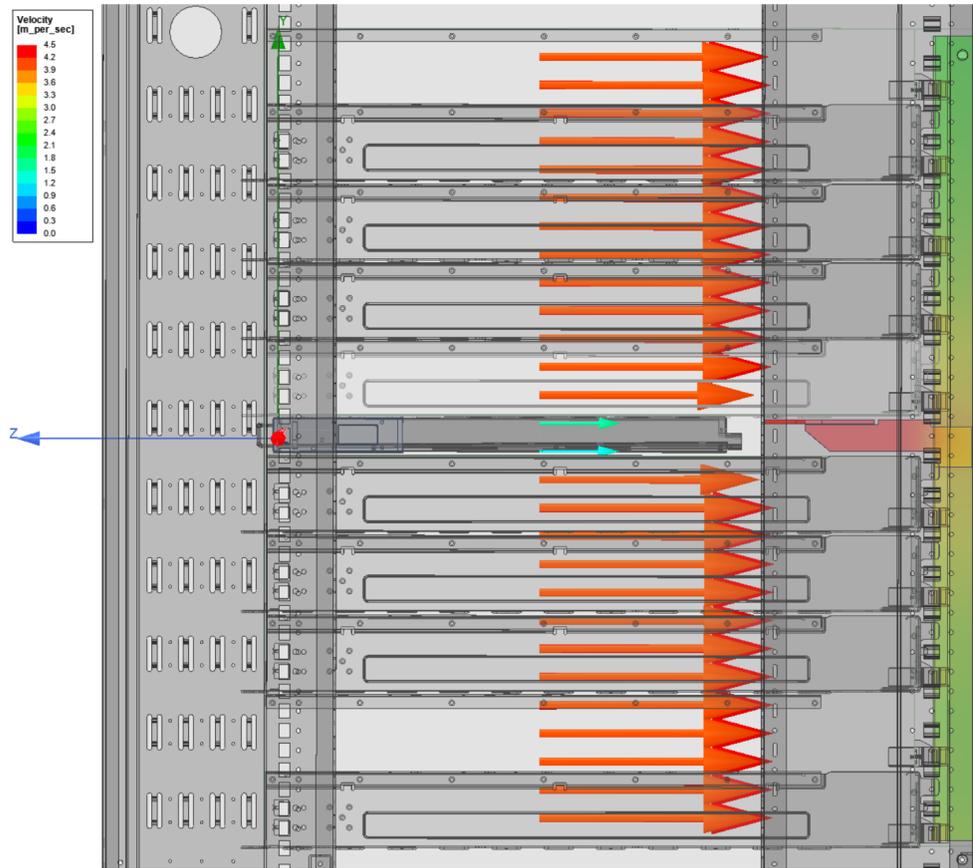
RACK & POWER

- Ansys Multiphysics coupling between Maxwell and Icepak
- Maxwell to calculate current distribution and power losses
- Icepak to import 3D loss map and perform Computer Fluid Dynamics (CFD) analysis



Case Studies

Simulation Setup – Airflow & Mesh



- Airflow per server = 30L/s (max capability 60L/s)
- Airflow per power zone = 900L/s (30 servers)
- Airflow speed in power zone = 3.6m/s
- Airflow in power shelf = 38L/s
- Airflow speed in power shelf = 1.7m/s

- CAD detailed Mesh - precise fits the CAD geometry
- Simplifications implemented to avoid mesh crowding in areas out of interest

Simulation Setup & Temperature Limits

- Open Rack Standard 2.0 - 3mm/12V silver plated busbar
- Standard Clips (silver plated) Res = 0.3mΩ
- Cold aisle temperature = 35°C
- **Temperature Limit busbar = 90°C if the busbars are plated**
- This is under UL subject 1801 and IEC 61204.

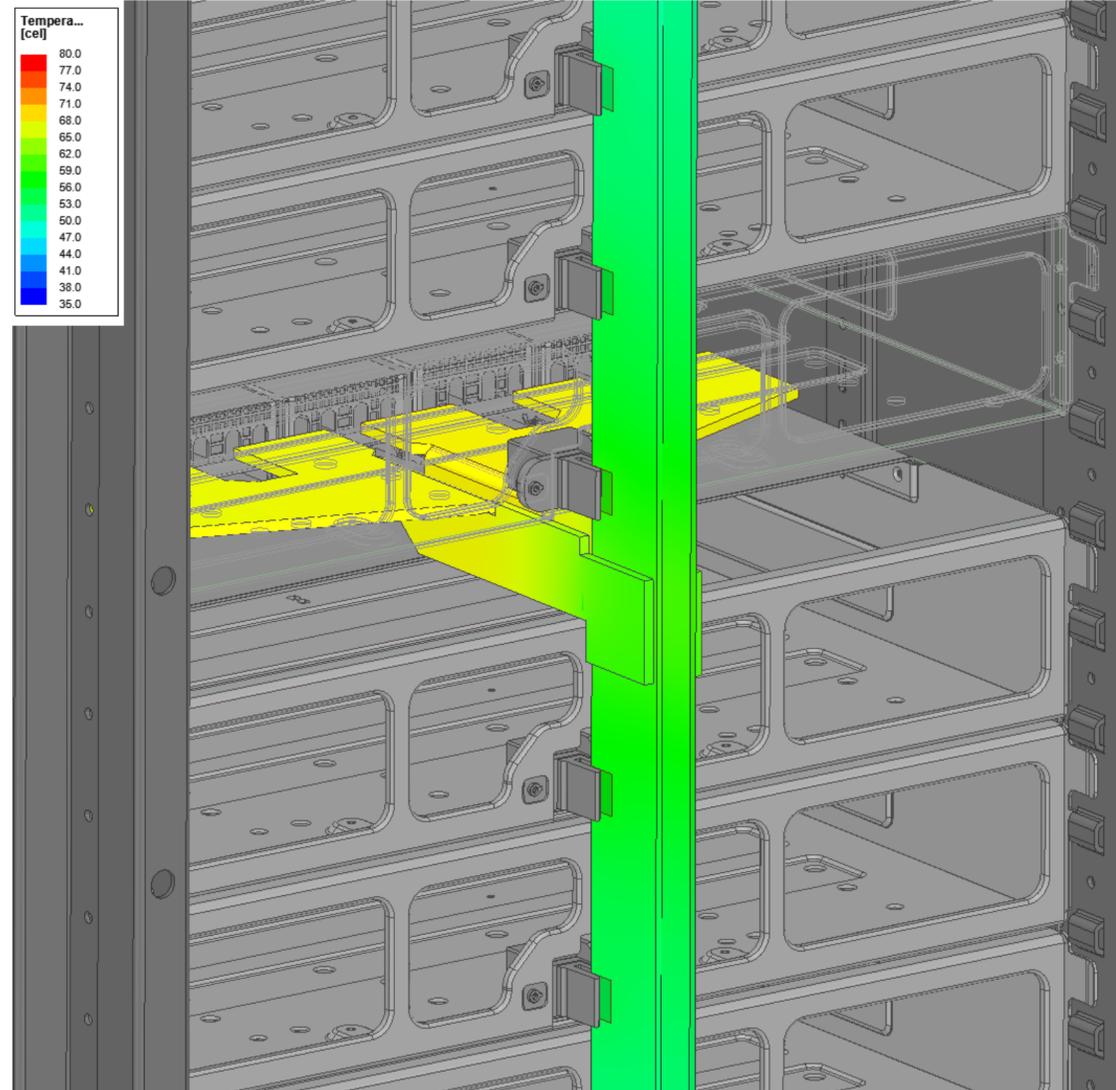
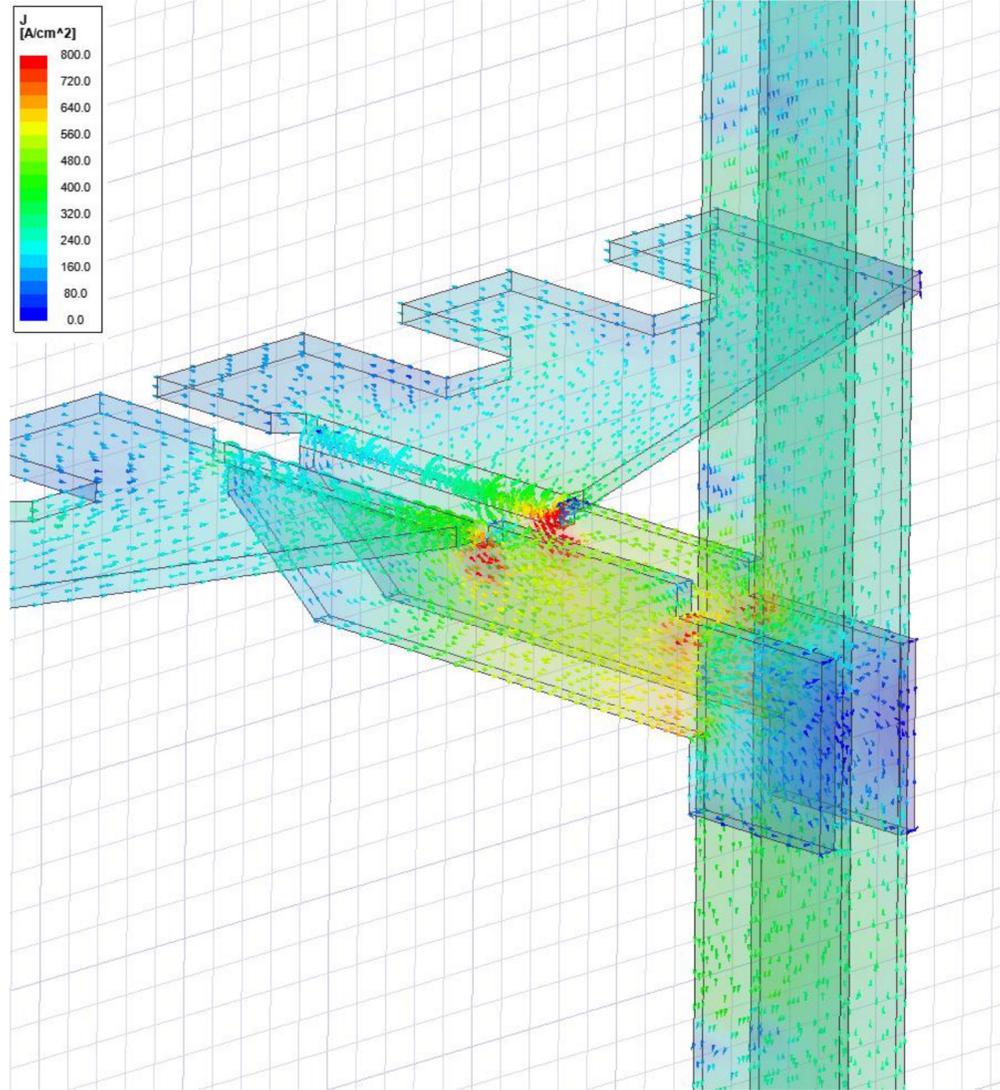
PS-E.4.5 Thermal requirements

The temperatures under normal operating conditions, shall not exceed the limits given in 4 (Table 4B/RD) of this standard and the Table PS-E.4B.101.

Table PS-E.4B.101 – Temperature limits

Parts	Maximum temperature °C
Contact parts in air	
Copper ^b	70
Silver or Silver-faced ^c	-
All other metals ^d	-
Busbars: ^h	
Unplated bus bar or unplated joint ^g	70
Plated bus bar joint, point of connection to a circuit breaker ^{a, e} and ^f	90
Terminals for field-installed conductors:	
Intended for use with 60 °C wire	75
Intended for use with 75 °C wire	90
Wire insulation or any part that can be contacted by field wiring	Temperature marking of the wire

Simulation results Config 3 - 23.4 kW Rack



- Load zone 1 = 30*410W
- Load zone 2 = 27*410W
- Total Power delivered = 23.4kW

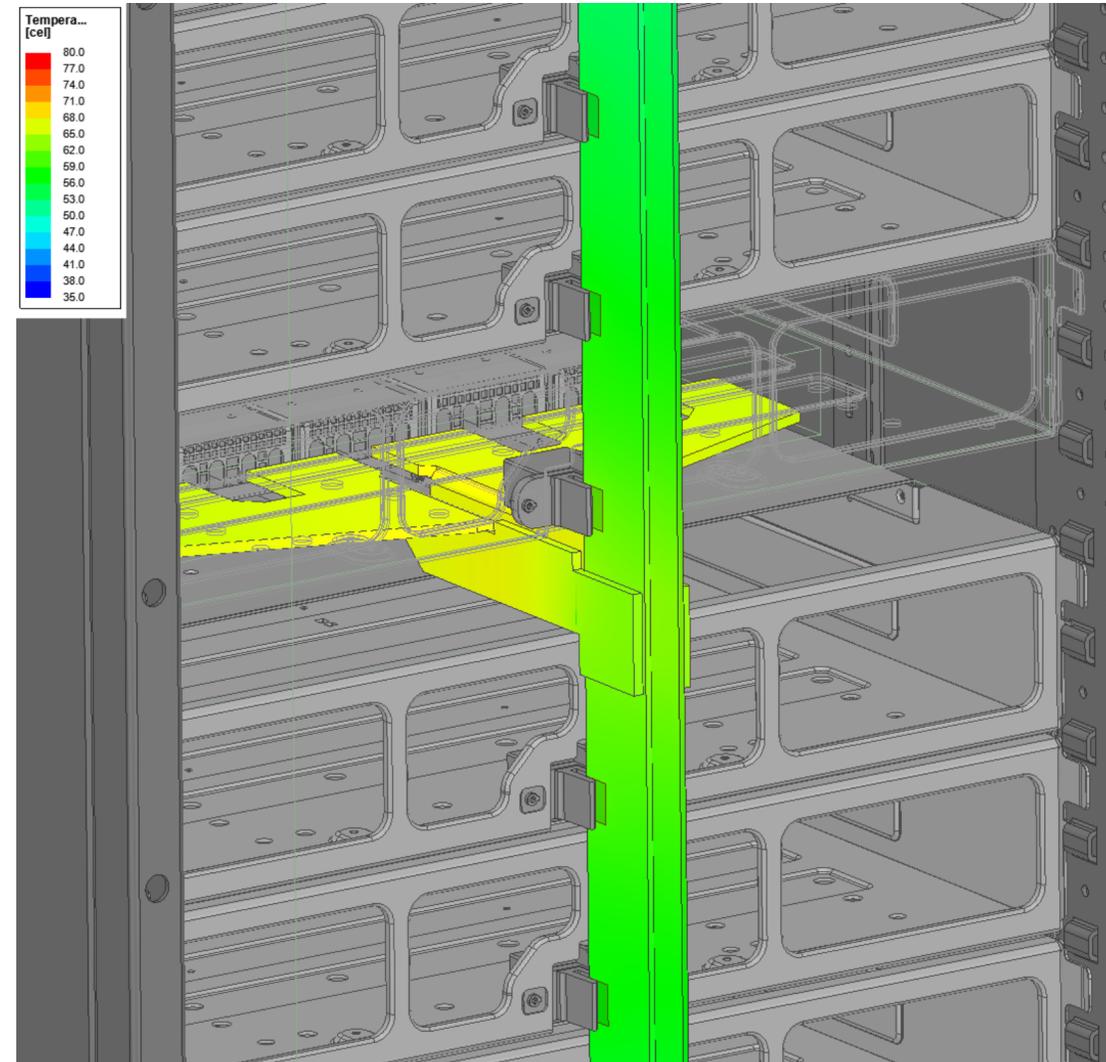
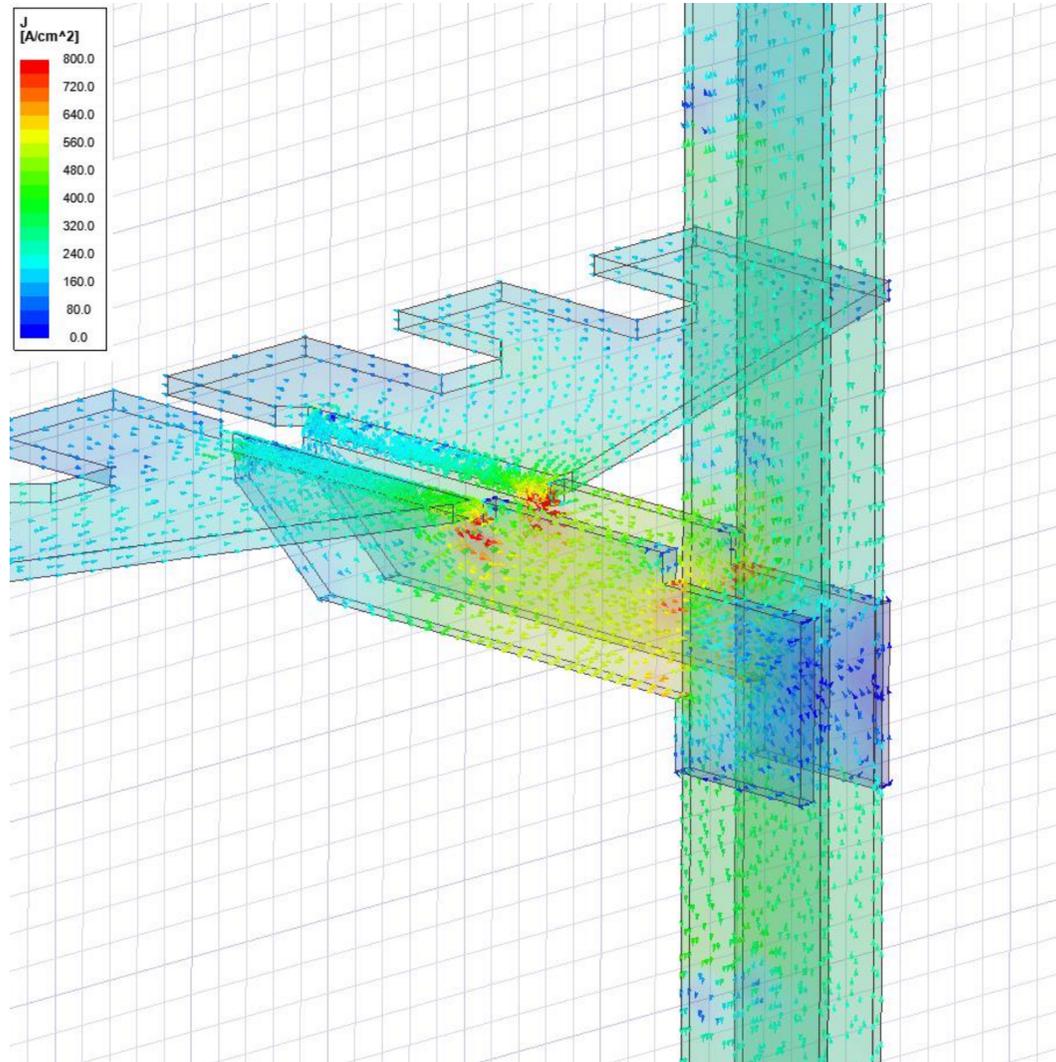
- Load current zone 1 = 1025A
- Load current zone 2 = 922A

- Bus Bars Power loss = 20.5W
- Hot spot = 58°C

- Power Shelf bus bars loss = 34.2W
- Hot spot = 65°C

- Clip losses: 2.9W/clip

Simulation results Config 4 - 22.5 kW Rack



- Load zone 1 = 30*395W
- Load zone 2 = 27*395W
- Total Power delivered = 22.5kW

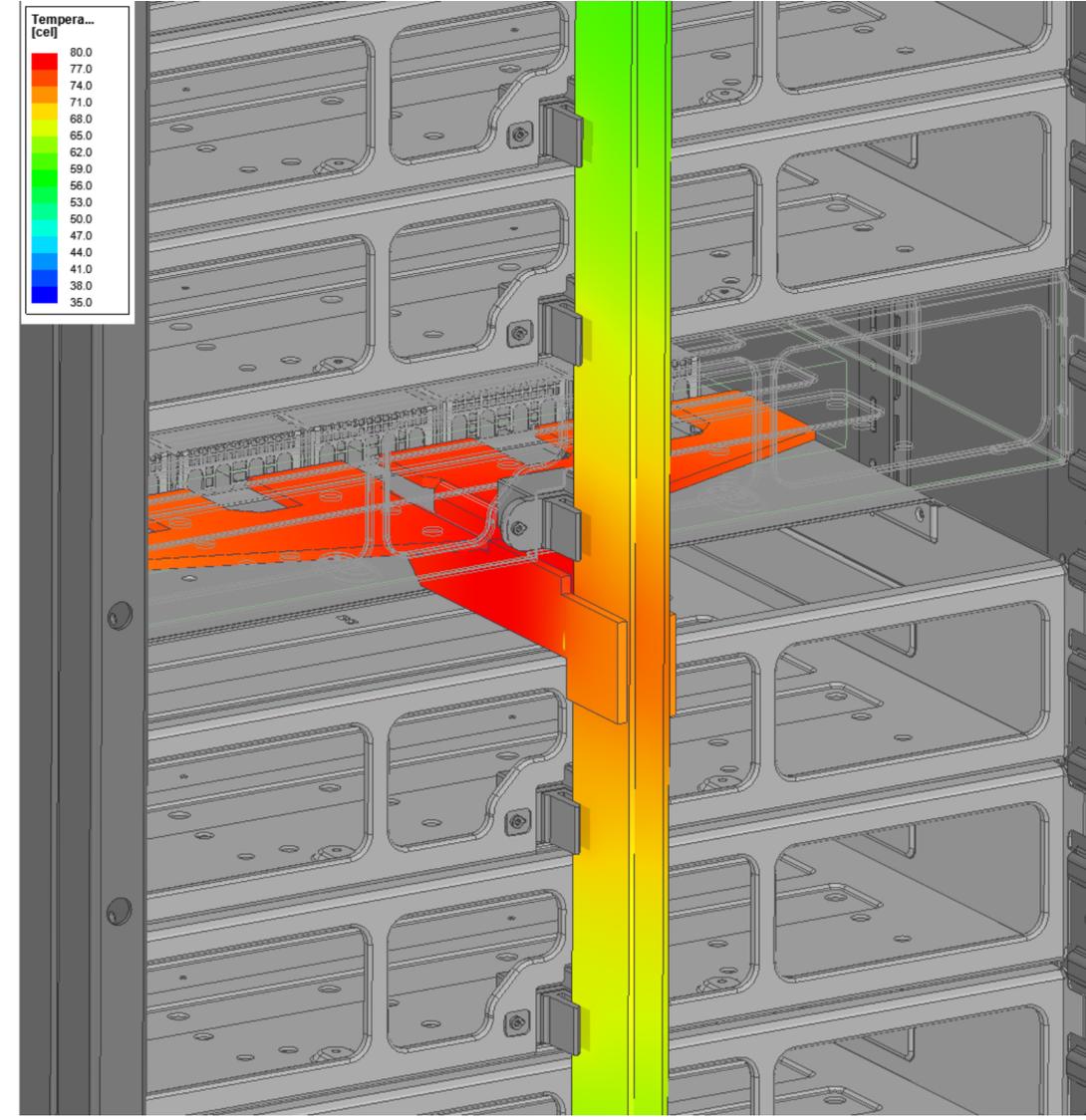
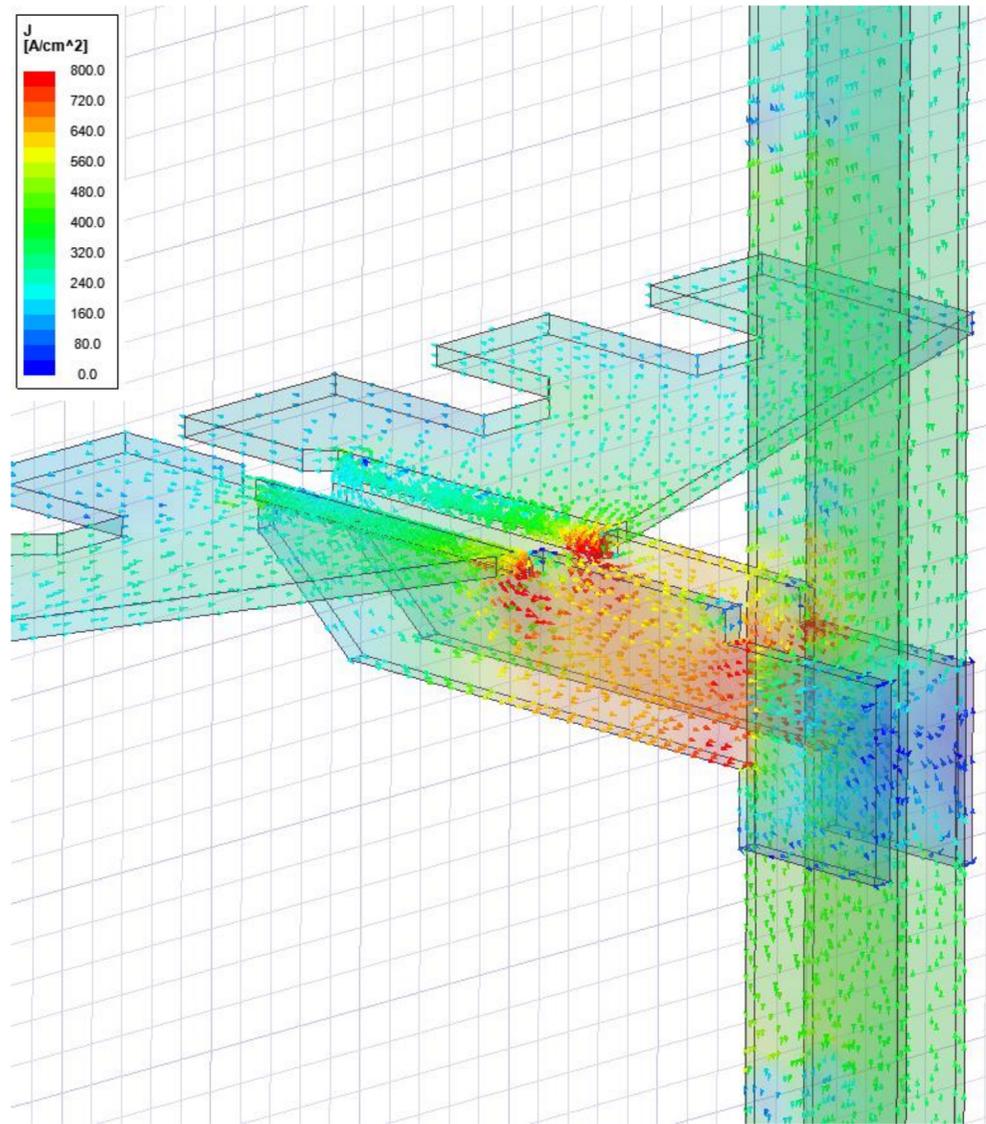
- Load current zone 1 = 987A
- Load current zone 2 = 888A

- Bus Bars Power loss = 19W
- Hot spot = 56.8degC

- Power Shelf bus bars loss = 31.8W
- Hot spot = 63.1degC

- Clip losses = 2.7W/clip

Simulation results Config 5 – 27.9kW Rack



- Load zone 1 = 30*490W
- Load zone 2 = 27*490W
- Total Power delivered = 27.9kW

- Load current zone 1= 1200A
- Load current zone 2 = 1100A

- Bus Bars Power loss = 29.3W
- Hot spot = 72degC

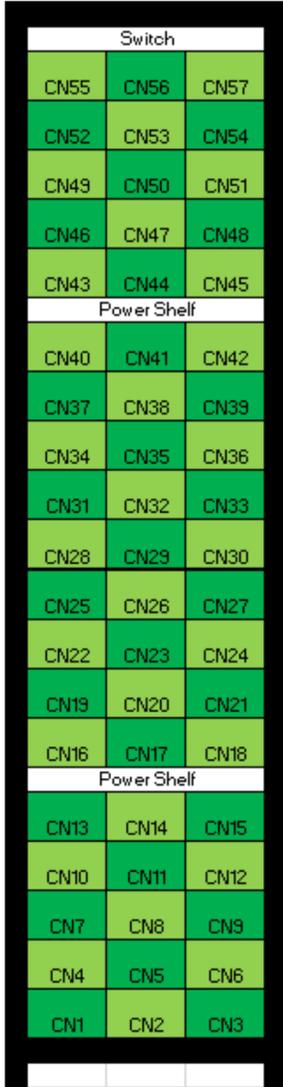
- Power Shelf bus bars loss = 48.9W
- Hot spot = 77degC

- Clip losses = 4.1W/clip

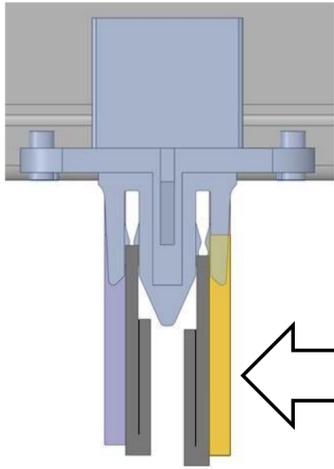
Config. 6 – Max Shelf Power Capability



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Amount	Part Number	min weight	max weight	idle power (W)	max power (W)
2	Bel Power Solutions SPSPFE3-08 Power Shelf	NA	300	NA	18000 (5+1)
12	Bel Power Solutions PFE3600-12-069RA	NA	NA	NA	3600
1	19" switch kit	0	0	NA	NA
19	Cubby for 3 server	266	266		
30	TBD	TBD	TBD	TBD	18000
27	TBD	TBD	TBD	TBD	16200
	total				34200



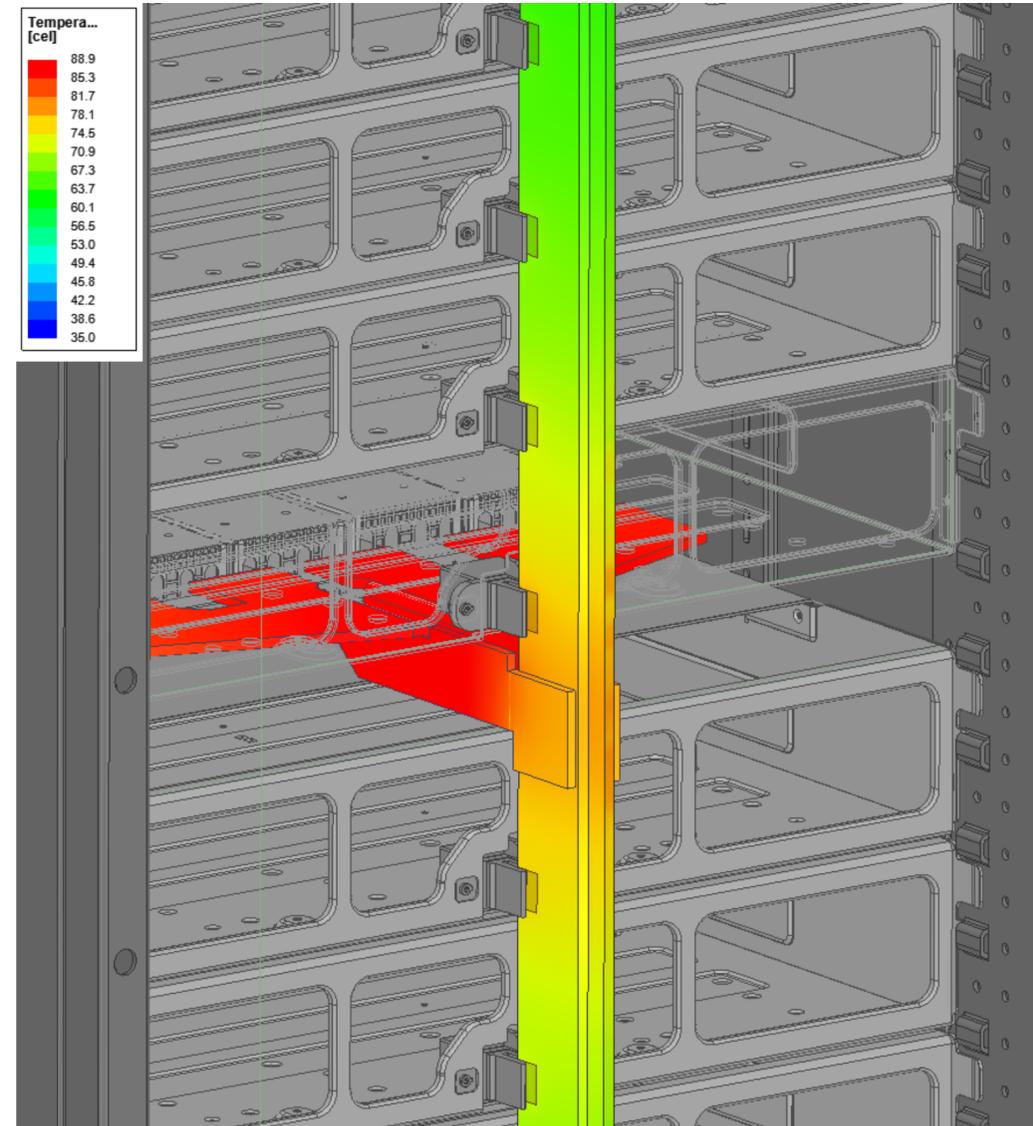
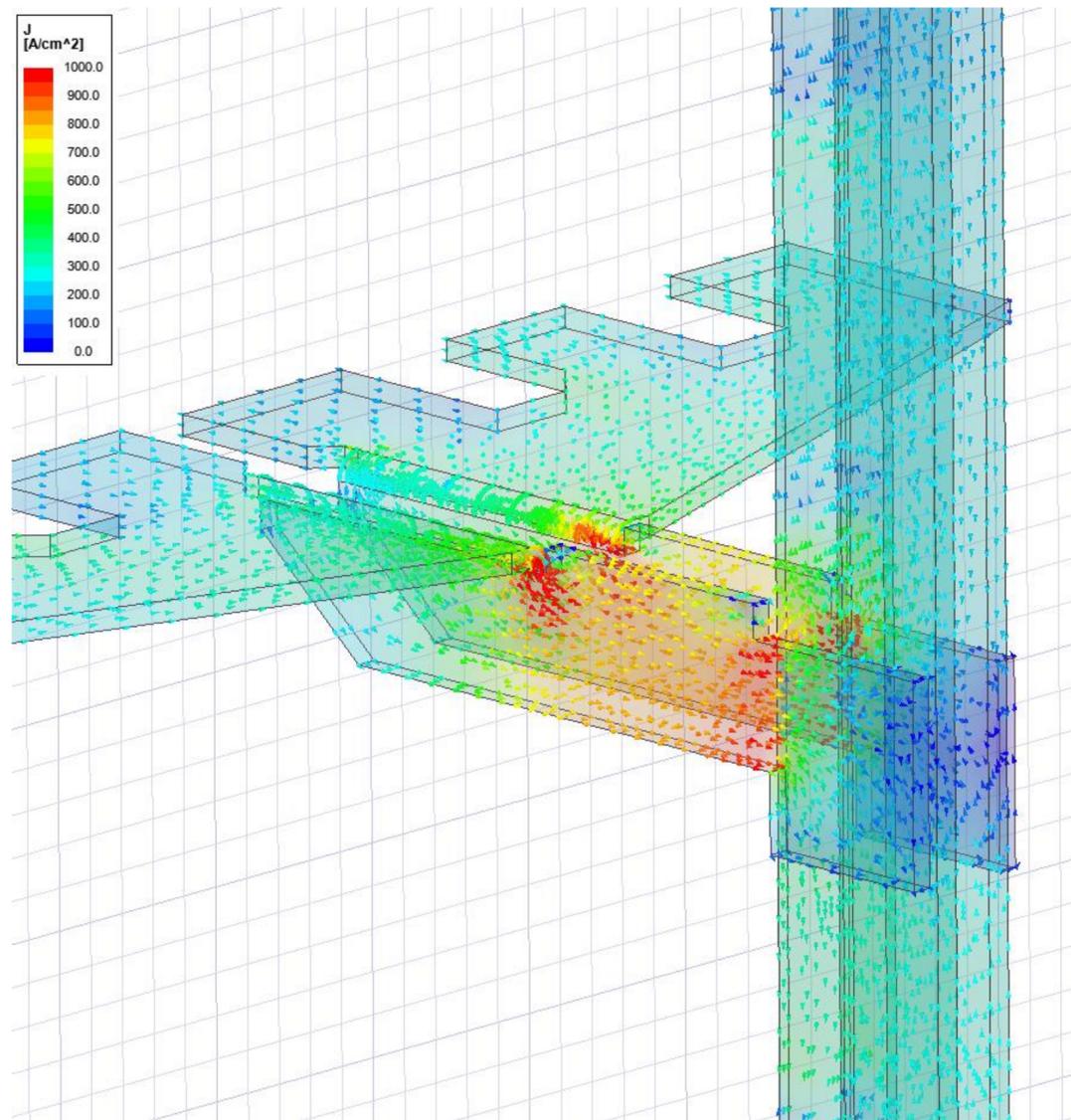
← Improved busbar

- 600W max server (hypothetical approach)
- 5+1 3.6kW PSU = 18kW limit per zone
- Airflow in servers increased 20% = 36L/s (max 60L/s), 4.3m/s)
- Vertical busbar cross section increased 2X outside the clips area



Case Studies

Simulation results Config 6 – 34.2kW Rack



- Load zone 1 = 30*600W
- Load zone 2 = 27*600W
- Total Power delivered = 34.2kW

- Load current zone 1 = 1.5kA
- Load current zone 2 = 1.3kA

- Bus Bars Power loss = 28.8W
- Hot spot = 79.9degC

- Power Shelf bus bars loss = 73W
- Hot spot = 87.5degC

- Clip losses = 6.2W/clip

Conclusion

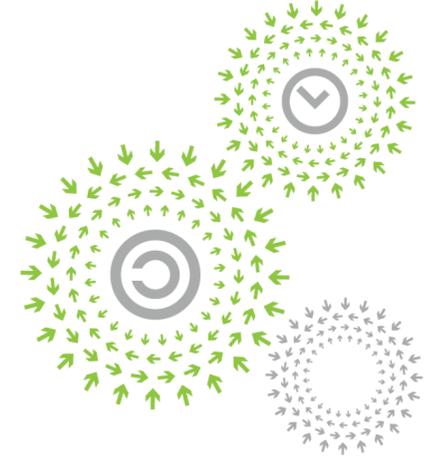
- FEM simulations are a key element to explore the power capability of new rack configurations
- Circle B , Rittal, Bel Power Solutions can provide fully equipped racks and if required simulations to estimate in advance power losses and temperatures
- The 12V power distribution of the rack and power shelf bus bars (excluding clips) of the Open Rack Standard 2.0 provided by Rittal in conjunction with the Bel Power Solutions Power Shelf (SPSPFE3 family) can cover without any HW change the configuration with the highest TDP available (27.9kW in the rack)
- With a modification of the 12V vertical busbar it is possible to achieve up to 18kW on each power zone resulting to 36kW per rack.

Standard R-OCP V2 Rack



Units [OU]	41	41
Width [mm]	600	600
Height [mm]	2246	2246
Depth [mm]	1068	1068
Supply includes	OCP V2 rack, without busbar for individual configuration	OCP V2 rack, inc. mounted 12 V DC busbar with 2 power zones
Max. load capacity (dyn)[N]	15.000	15.000
Nominal power [kW]	-	6,6 / 13,2
Model No.	7100200	7100221
Product-specific scope of supply		
1 x 12 V DC busbar	-	•
Also required		
12 V DC OCP busbar	7100312	-

<https://www.rittal.com/it-solutions/en/solutions/detail/show/Loesungen/ocp-open-compute-project/>



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Circle B – Solution Provider in Europe

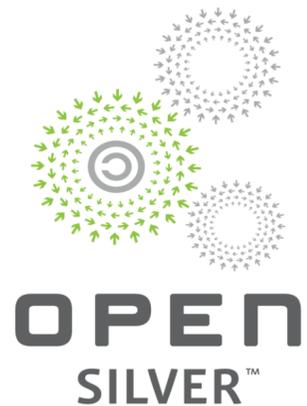
Visit our website:

CircleB.eu

Or the OCP Marketplace:

[Open Rack v2 - AC Bundle](#)

[Wiwynn SV7220G3 Server](#)



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Power Shelves Product Family



- 1 Open U Power Shelves
- 18kW in 5+1 redundancy (3kW and 3.6kW power modules)
- Dual 3-phase AC inputs with Y or Δ (208V line to line) configuration
- HVdc input
- 48Vdc input
- Single or triple 12V busbar option
- Ethernet Controller
- Paralleling capability (active power sharing) between shelves



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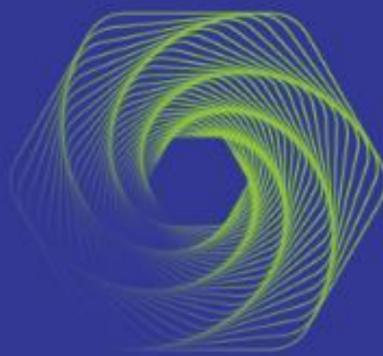
<https://www.belfuse.com/open-compute-data-center-solutions>



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