ROCKY MOUNT, NC
THE CENTER OF IT ALL

Bitcoin mining

March 8, 2023 Khalil Matar - EE

Summary of Presentation

A) City of Rocky Mount is currently working to serve what likely will be our largest commercial customer, a bitcoin mining operation.

<u>Technical aspects of serving this customer:</u>

1) Definition of bitcoin mining & POD,
2) Pictures of site development & Project Progress,
3) Customer equipment specifications,
4) Load type,
5) POD arrangements and load staging,

Summary of Presentation

6) Feeder design,

7) Transformer needs, and

8) Load Management considerations.

Summary of Presentation

B) Precautions and technical concerns for investors & for utilities when serving crypto currency mining operation:

1) Customer equipment and non-standard voltage solutions (e.g., voltage control),
2) Harmonic effects on utility equipment and other customers,
3) Impact of PF leading on feeder voltage, and
4) Environmental concerns,
5) Public Concerns/Audible sound level.

C) Q/A

Definition of bitcoin mining & POD

Bitcoin mining:

- Process to validate Bitcoin transactions on the network & to add the results to the blockchain ledger.
- Validation is done by solving complex cryptographic hash puzzles to verify blocks of transactions that are updated on the decentralized blockchain ledger.
- In return, miners are awarded a certain number of bitcoins per block.

Bitcoin Mining POD

Bitcoin Mining POD

- POD = “Proof of delivery” container,
- Powerful computers, Fast & high-capacity RAMs,
- Air filters on both sides
- Cool air in POD from the sides,
- Hot air out of POD from Hood.

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Site before project – October 2022

Original site in October 2022

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Site Clearance - October 2022

Tree removals →

Site December 2022

December 2022 →

Customer´s equipment specifications

Customer´s equipment specifications:

1. Powerful computers.
2. Fast & high-capacity RAMs.
3. Voltage: 255 Volts AC - LG (as requested by customer)
4. Power: 3250 watts / unit.
5. Not all units have the same capacity & specs.
6. Equipment manufactured outside the USA.
7. Nowadays one of the greatest nonlinear consumers of electricity is equipment for cryptocurrency mining.

Load type

Load type/characteristics:

1. 2 MW/POD (depending on number of units & specs in each POD).
2. Non-linear load.
3. Capacitive load/Leading PF.
4. 24/7 operation (no cooling time for utility facilities).
5. Max demand varies depending on cooling fans on units.
6. Customer committed to remove units in case of overload on transformers.

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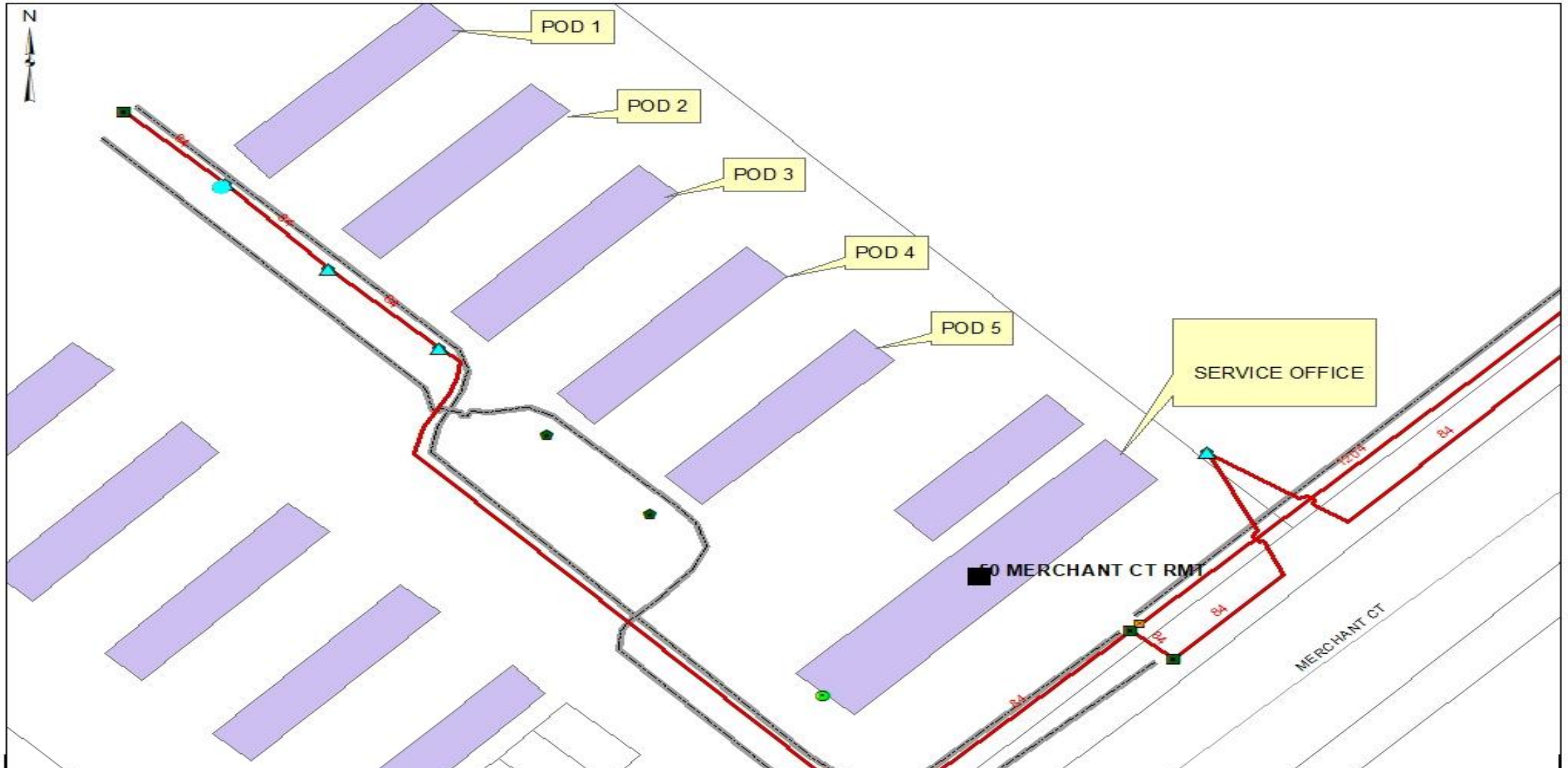
POD arrangements & load staging



Feeder design

1) **Feeders:** City extended 2 existing distribution feeders and made minor modifications to provide the required electric service,
2) **First stage:** 1 feeder for 3 PODs and another feeder for 2 PODs,
3) **Transformers:** 2500KVA, 277/480V (GND Y/GND Y) for each POD (Transformer tap was set to 105% to lower service voltage in order to meet the customer's voltage requirement) (5% voltage reduction on transformers),
4) **Derated "non-K rated" Transformers** to 80% of their capacity (to be monitored in summer time in case of overheating),
5) **Customer wanted** Delta/Y distribution transformer for suppression of harmonics.

Feeder design

6) **Voltage regulators:** Voltage regulator bank was installed near the customer's site.

   Settings: 118.5V, BW=2 volts on 120V base. Regulators settings were changed to 119.5V based on Customer's request, (Avg. voltage on customer's side = 259V LG),

7) **Ramp up / down:** Customer has the capacity to ramp up / down his load within the same POD to avoid voltage flicker/spike during load management,

8) **Meters:** One secondary meter/Transformer (No primary meter)/Large general service agreement. No KVAR consumption on meter (capacitive load), and

9) **Customer's future plan:** To add 5 more PODs (this will require an express feeder or most likely a substation).

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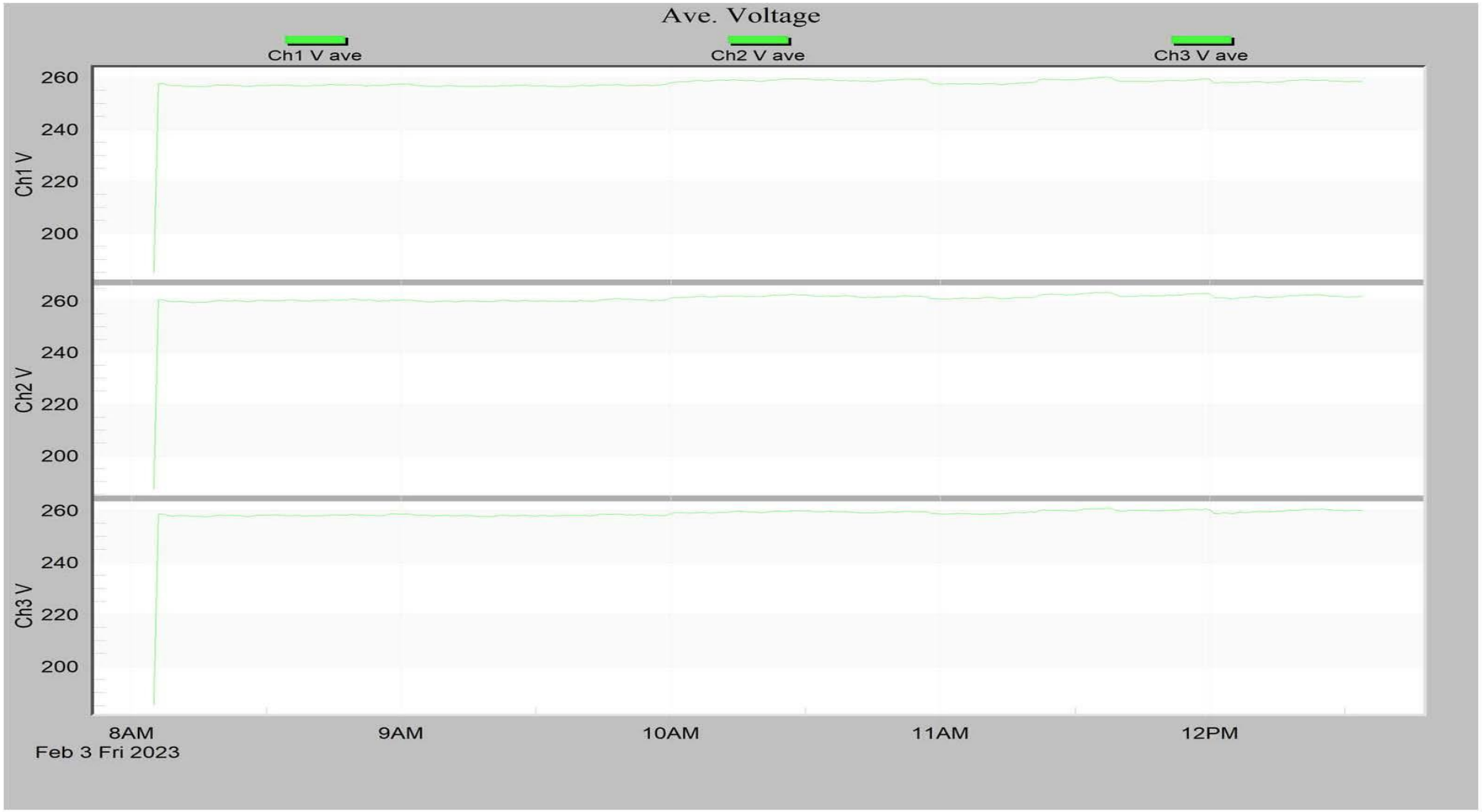
Voltage at Transformer
V LG= 258-260V



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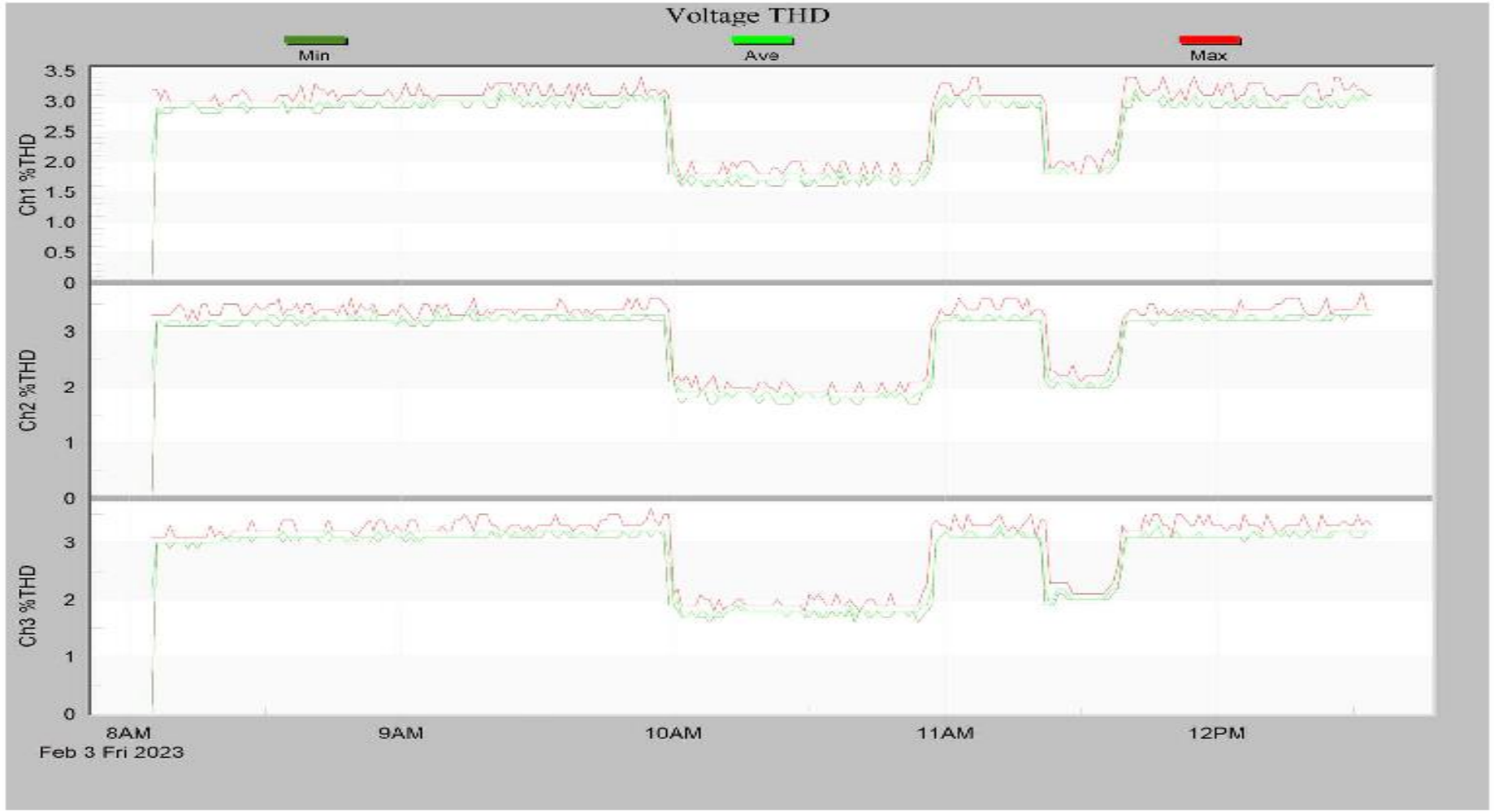
Voltage THD
Avg. 3.1% / 800KW



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Primary current

POD 1 Transformer 1 2500 KVA	Primary Amps			
	A	B	C	Neutral
Load : 242 Machines 800 KW Date: 1/31/2023	35.4	36.0	36.4	9.6 (26.6% of phase)
Load : 380 Machines 1,235 KW Date: 2/9/2023	56.5	56.1	57.5	15.1 (26.6% of phase)

Voltage Harmonics

IEEE 519-2022 Voltage harmonic limits

Bus voltage V at point of common coupling	Individual harmonic (%)	Total harmonic distortion THD (%)
V ≤ 1.0 kV (at secondary/800KW) (at secondary/1,333KW) At POD 1 Transformer	5.0 (measured=---) (measured=---)	8.0 (Avg. measured=3.1)* (Avg. measured=4.4)

(*) POD 2 Transformer: Average measured THD of 2.4% on secondary side at no load.

Current Harmonics

IEEE 519-2022 Current distortion limits (system rated 277V-LG)

ISC/IL at PCC	Harmonic limits 2 ≤ h < 11	TDD
<20 1,333KW	4.0 (Avg. Measured= ---)	5.0% (Avg. Measured= 1.0%)

Avg. measured THD current %: 11.27 %

3rd harmonic measured current: 180 A

5th harmonic measured current: 56 A

7th harmonic measured current: 20 A

Load Management considerations

Load Management considerations:

1) Customer agreed to apply load management when the City request that,

2) City send a signal to customer to apply load management,

3) Customer has the capability to apply load management locally/remotely, and

4) Customer ramps up/down the loads within same POD & one POD at a time.

Precautions & technical concerns

Precautions & technical concerns:

1) Customer's equipment and non-standard voltage solutions (e.g., voltage control),

2) Harmonic effects on electric utility equipment and other customers,

3) Impact of leading PF on feeder voltage, and

4) Environmental/Public concerns.

Precautions & technical concerns

1) <u>Customer's equipment and non-standard voltage solutions (e.g., voltage control):</u>

a) Use voltage regulators & Transformer taps to regulate the voltage.

b) US manufacturers entered the crypto mining chip business,

c) US chips are 1000 times faster, more energy efficient than those manufactured outside USA, and

d) US made chips/processors meet US standards,

Precautions & technical concerns

2) Harmonic effects on utility equipment and other customers:

a) Current harmonics come from the load, causing increased eddy current and hysteresis losses in transformers resulting in losses and over-heating, and overloading the neutral conductor,
b) Current distortion causes overheating in facilities and shortens lifetime of equipment (such as transformers),
c) Current distortion causes voltage distortion,
d) Voltage distortion causes mis-operation/disruption of equipment, and
e) Problem of harmonic distortion depends on magnitude of distortion.

Precautions & technical concerns

IEEE 519-2022 Voltage distortion limits

Bus voltage V at point of common coupling	Individual harmonic (%)	Total harmonic distortion THD (%)
V ≤ 1.0 kV	5.0	8.0
1 kV < V ≤ 69 kV	3.0	5.0
69 kV < V ≤ 161 kV	1.5	2.5
161 kV < V	1.0	1.5

Precautions & technical concerns

IEEE 519-2022 Current distortion limits (up to 69KV)

ISC/IL at PCC	Harmonic limits 2 ≤ h < 11	Harmonic limits 11 ≤ h < 17	Harmonic limits 17 ≤ h < 23	Harmonic limits 23 ≤ h < 35	Harmonic limits 35 ≤ h ≤ 50	TDD
<20	4.0	2.0	1.5	0.6	0.3	5.0
20<50	7.0	3.5	2.5	1.0	0.5	8.0
50<100	10.0	4.5	4.0	1.5	0.7	12.0
100<1000	12.0	5.5	5.0	2.0	1.0	15.0
>1000	15.0	7.0	6.0	2.5	1.4	20.0

Precautions & technical concerns

3) **Impact of leading PF on feeder voltage:**

a) No impact

b) PF = 99 % leading

Precautions & technical concerns

4) **Environmental/Public concerns:**

a) **Tree removals:** clearing the site for construction,

b) **Heat from POD:** processors create a lot of heat sometimes temperature inside PODs reaches very high degrees, and

c) **Public disturbance/Audible noise from fans.**

Precautions & technical concerns

4C) Environmental/public concerns:

Audible noise levels:

1) **At entrance of site:** 41 Db at 5:30AM - before bitcoin mining operation started.

2) **With 242 machines operating at POD 1:**
   a) 44.4 Db at entrance of site
   b) 70.4 Db at left front side of POD 1
   c) 68.8 Db at right front side of POD 1
   d) 60.4 Db at back side of POD 1

Precautions & technical concerns

44.4 Db at entrance of site (242 Machines)

Precautions & technical concerns

left & right front side of POD 1 (242 Machines)

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Recommendations

1) **Investors:**

a) Buy American made processors to meet US standards/efficiency,

b) Select a large site that is far enough from residential, commercial or industrial areas to avoid public disturbance. Even if zone allows,

c) Change method of cooling to reduce audible noise, and

d) Use Isolation/soundproof walls to reduce audible noise.

Precautions & technical concerns

2) Utilities:

a) Use dedicated feeders or dedicated substations for large operations to avoid harmonic distortion and service quality problems, and

b) Transformers:

* **Use Delta/Wye transformers** for suppression of harmonics,

* **De-rate "non K-Factor Transformer":** de-rated power transformers to 70%,

* **Use "K-Factor transformer":** Standard IEEE C.57.110 - 2018, and

* **K-Factor transformers** include: neutral design up to 200% neutral connections, design windings/core/insulation to lower all current losses, (test it thru independent certified agency).

Precautions & technical concerns

3) Rules/Regulations:

a) Issue standards/rules/regulations on crypto mining operations especially their impact on customers/residents.

C) Questions/Answers?

Thank you

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Connections Summit Breakout Session #3 Feedback