Evaluation of Dimmable LED Streetlights

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1.0 Abstract ……... 3
2.0 Background ……... 3
3.0 Introduction ……..……....3
4.0 Cost ……...3
5.0 Installation and Configuration …..……..……..4
6.0 Connectivity ……..……..5
7.0 Data and Trends ……..……...6
8.0 Troubleshoot ……...8
9.0 Risks and Stakeholders Engagement……9
10.0 Summary……..……..10

1.0 Abstract:

In accordance with Connecticut Public Utilities Regulatory Authority and Dark Sky Association, Eversource Energy conducted a pilot to evaluate dimmable LED technology and to file a report with recommendations in the Company's next rate case proceeding. The pilot involves installation and operation of a wireless gateway and 10 Street Lights Controls (SLCs), on Eversource's Berlin Campus in Connecticut. This report evaluates the functionality and installation of dimmable LED technology and does not cover energy savings or any rate calculations.

2.0 Background:

Dark Sky Association has been an advocate for reduction in light pollution and a promoter for protection of nighttime environment. Light pollution, as defined by Dark Sky Association, is the "inappropriate use of artificial light at night – is an environmental pollutant that harms our planet and robs us of the opportunity to experience the wonder of a natural night sky."

Eversource Energy researched several dimmable LED technologies and agreed to conduct the pilot with CIMCON Lighting. CIMCON Lighting has 25+ years of experience in software and controls with a goal of developing "Smart Cities". In addition, CIMCON Lighting provides an economical approach to create a wireless network with technology that retrofits on existing LED fixtures to implement Smart City solutions.

3.0 Introduction:

The pilot is a result of an agreement with Connecticut PURA and Dark Sky Association. T&D Engineering Standards agreed to evaluate the dimmable LED street light technology provided by CIMCON Lighting. The pilot was developed in phases which include initiation, access, network design and staging, along with deployment and training. The technology includes a wireless gateway and 10 Street Light Controls or SLCs. The wireless gateway is cellular and includes a Verizon sim-card that runs on a 1G plan. The SLCs are equipped with GPS locators for tracking. The gateway along with the controllers follow a Mesh Topology. Thus, to ensure an ideal communication between the gateway and the controllers, the controllers should be installed in a concentric fashion originating from the gateway location. Through this topology, the wireless gateway can communicate with 500 SLCs.

4.0 Cost:

The cost for the gateway is approximately $1,500 and the cost for remote set-up and commissioning of gateway and migration of existing nodes is approximately $550.00 at the time of the pilot.

Expansion of this pilot would require additional cost considerations. Transitioning to a dimmable offering would necessitate the development and approval of a new tariff. . The implementation costs associated with dimmable controls would need to be addressed in this tariff.

New tariff would also need to include considerations for the variability in operational schedules and dimming percentages. Another potential cost not explored in this pilot is the compatibility/need for new fixtures. Aside from the gateways and nodes as additional cost that may not have an incentive as we have already converted to LED's. It's essential to carefully evaluate the impact on cost savings when considering such changes.

5.0 Installation and Configuration:

Eversource Energy received one wireless gateway, 20 SLCs, and online access to a software called LightingGale from CIMCON Lighting. Eversource Energy incorporated the mesh topology layout between the cellular gateway and the 10 SLCs in accordance with the existing layout of LED street lights installed on Eversource's Berlin campus to establish an optimum wireless communication. The gateway was installed on the top of the most central pole to allow for ideal connectivity between the gateway's antenna and the 10 SLCS. The street light controls are 3-pinned that fit onto the existing LED fixture's NEMA photocell receptacle. Each of the 10 SLCs have an associated SLC number for identification. **Figure 1** shows the layout of the wireless gateway and the 10 SLCs on the entrance driveway to the Eversource Energy building in Berlin, Connecticut.



Figure 1 – Layout of Wireless Gateway and 10 SLCS

After establishing a power connection for the wireless gateway and installing all 10 SLCs, Eversource Energy accepted the transfer of service from CIMCON Lighting for the Verizon 1G plan for the wireless gateway. The wireless gateway and the 10 SLCs were then linked and configured to the LightingGale software for accessibility and control. The equipped GPS is also linked with the software which allows the users to locate the installed wireless gateway and all SLCs on the software as shown in **Figure 1.**

6.0 Connectivity:

The user sends various commands through the software to the wireless gateway to control all SLCs or a specific number of SLCs. The wireless gateway receives the Radio Frequency (RF) signal and identifies the selected SLC(s). Thereafter, the selected SLC(s) receives command from the wireless gateway. One can confirm that the command has been successfully completed through the software. **Figure 2** shows an overview of the connectivity between the software, gateway, and all SLCs. The manufacturer demonstrates that the firewall blocks certain kinds of network traffic by creating a barrier between a trusted and an untrusted network.

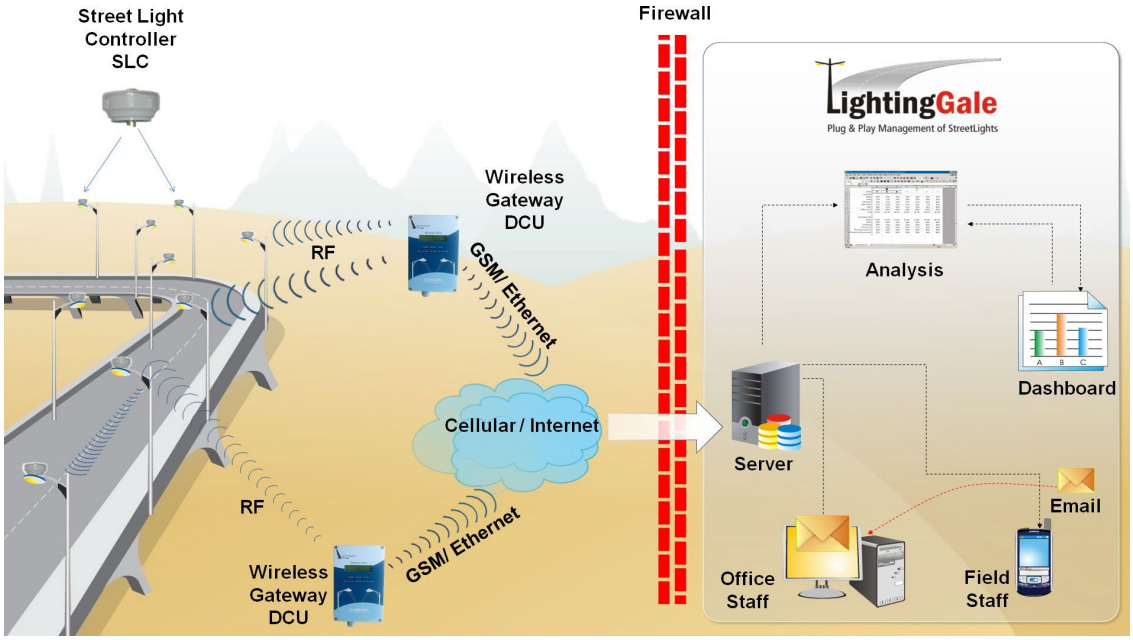

Figure 2 – Connectivity Overview (Image provided from CIMCON Lighting)

The various commands can be divided into troubleshooting commands and operational commands. The troubleshooting commands are discussed in **Section # 7: Troubleshoot**. The operational commands include on/off and percent dimming. The user will select the SLC(s) and send the desired command. **Figure 3** shows all 10 configured SLCs with their associated SLC number and MAC address. In addition, the user can set a timely schedule for the command to take place. For instance, one can set 5 SLCs to dim to 50 percent at midnight for two weeks.

SLC#	SLC Name	Address	Gateway	Group	MAC Address	Lamp Type
Select	Select	Search	Select	Search	Search	Select
23853	23853	12 Selden St, Berlin, CT 06037, USA	Berlin GW		000D6F00114418F7	LED
23935	23935	107 Selden St, Berlin, CT 06037, USA	Berlin GW		000D6F001083B31B	LED
24149	24149	107 Selden St, Berlin, CT 06037, USA	Berlin GW		000D6F00115A059D	LED
24228	24228	12 Selden St, Berlin, CT 06037, USA	Berlin GW		000D6F0011442A01	LED
27010	27010	107 Selden St, Berlin, CT 06037, USA	Berlin GW		000D6F0010839C3C	LED
27015	27015	12 Selden St, Berlin, CT 06037, USA	Berlin GW		000D6F001147ABAE	LED
27016	27016	12 Selden St, Berlin, CT 06037, USA	Berlin GW		000D6F0010841DF7	LED
27020	27020	12 Selden St, Berlin, CT 06037, USA	Berlin GW		000D6F001084210D	LED
27021	27021	107 Selden St, Berlin, CT 06037, USA	Berlin GW		000D6F00114767AF	LED
27023	27023	12 Selden St, Berlin, CT 06037, USA	Berlin GW		000D6F001083E9D6	LED

Figure 3 – Ten Configured Street Light Controls

7.0 Data and Trends

The software records several measured parameters such as voltage, current, watts, cumulative kilowatt hours, burn hours, percent dimming, lamp status, communication, and driver. The user can export the collected data in form of an Excel sheet or in table/graph format. **Figures 4 and 5** show measured data exported to an Excel sheet for the specified SLCs. The percent dimming can be specified by the user. For example, 100 percent dimming means the light is off while 0 percent dimming means that the light is on to the fullest and is not set to any dimming level. One can see, from **Figures 4 and 5,** the differences in the measured parameters highlighted in red when set from 0 percent dimming to 50 percent dimming.

SLC#: 23853 Name: 23853 Detailed Report for the period of 09/01/2019 9:4:44 to 12/31/2019 9:4:44

Date -Time	Voltage (Volt)	Current (Amp)	Watts (Watt)	Cumulative KiloWatt Hrs (kWh)	Burn Hrs (Hrs)	Dimming (Per)	Mode	Lamp Status	Lamp	Communication	Driver	Tilt
12/31/19 8:19	120.28	0	0	69.89944	829.04	100	Astro Clock	OFF	Normal	OK	Normal	Normal
12/31/19 7:40	120.357	0	0	69.89944	829.04			OFF	Normal	OK	Normal	Normal
12/31/19 7:00	118.97	0.514	61.11	69.85944	828.24			ON	Normal	OK	Normal	Normal
12/31/19 5:59	118.883	0.515	61.19	69.79745	827.23	50	Astro Clock	ON	Normal	OK	Normal	Normal
12/31/19 4:59	119.019	0.514	61.21	69.73625	826.23	50	Astro Clock	ON	Normal	OK	Normal	Normal
12/31/19 3:59	119.586	0.512	61.27	69.67509	825.23	50	Astro Clock	ON	Normal	OK	Normal	Normal
12/31/19 2:59	119.825	0.512	61.29	69.61385	824.23	50	Astro Clock	ON	Normal	OK	Normal	Normal
12/31/19 1:59	119.852	0.511	61.29	69.55269	823.23	50	Astro Clock	ON	Normal	OK	Normal	Normal
12/31/19 0:59	120.044	0.511	61.29	69.49139	822.23	50	Astro Clock	ON	Normal	OK	Normal	Normal
12/30/19 23:59	119.935	0.511	61.32	69.43018	821.23	50	Astro Clock	ON	Normal	OK	Normal	Normal
12/30/19 22:59	120.142	0.51	61.27	69.36893	820.23	50	Astro Clock	ON	Normal	OK	Normal	Normal
12/30/19 21:59	120.017	0.51	61.25	69.30778	819.23	50	Astro Clock	ON	Normal	OK	Normal	Normal
12/30/19 20:59	120.075	0.51	61.26	69.24653	818.23	50	Astro Clock	ON	Normal	OK	Normal	Normal
12/30/19 19:59	120.071	0.511	61.3	69.18523	817.23	50	Astro Clock	ON	Normal	OK	Normal	Normal
...												
12/2/19 5:58	118.947	0.793	94.34	55.48514	593.52	0	Astro Clock with Photocell Override	ON	Normal	OK	Normal	Normal
12/2/19 4:58	119.704	0.788	94.27	55.39065	592.52	0	Astro Clock with Photocell Override	ON	Normal	OK	Normal	Normal
12/2/19 3:58	120.457	0.783	94.26	55.29625	591.52	0	Astro Clock with Photocell Override	ON	Normal	OK	Normal	Normal
12/2/19 2:58	120.482	0.782	94.24	55.20181	590.52	0	Astro Clock with Photocell Override	ON	Normal	OK	Normal	Normal
12/2/19 1:58	120.458	0.783	94.32	55.10745	589.52	0	Astro Clock with Photocell Override	ON	Normal	OK	Normal	Normal
12/2/19 0:58	120.293	0.784	94.24	55.01301	588.52	0	Astro Clock with Photocell Override	ON	Normal	OK	Normal	Normal
12/1/19 23:58	120.821	0.781	94.34	54.91861	587.52	0	Astro Clock with Photocell Override	ON	Normal	OK	Normal	Normal
12/1/19 22:58	120.785	0.782	94.45	54.82403	586.52	0	Astro Clock with Photocell Override	ON	Normal	OK	Normal	Normal
12/1/19 21:58	120.45	0.785	94.53	54.7294	585.52	0	Astro Clock with Photocell Override	ON	Normal	OK	Normal	Normal
12/1/19 20:58	120.169	0.786	94.49	54.63477	584.52	0	Astro Clock with Photocell Override	ON	Normal	OK	Normal	Normal
12/1/19 19:58	120.276	0.786	94.56	54.54005	583.52	0	Astro Clock with Photocell Override	ON	Normal	OK	Normal	Normal
12/1/19 18:58	120.251	0.787	94.65	54.44537	582.52	0	Astro Clock with Photocell Override	ON	Normal	OK	Normal	Normal
12/1/19 17:23	119.899	0.789	94.55	54.29546	581.17	0	Astro Clock with Photocell Override	ON	Normal	OK	Normal	Normal

Figure 4 – SLC Number: 23853

SLC#: 27016 Name: 27016 Detailed Report for the period of 09/01/2019 9:4:44 to 12/31/2019 9:4:44

Date -Time	Voltage (Volt)	Current (Amp)	Watts (Watt)	Cumulative KiloWatt Hrs (kWh)	Burn Hrs (Hrs)	Dimming (Per)	Mode	Lamp Status	Lamp	Communication	Driver	Tilt
12/31/19 8:19	121.197	0	0	91.40268	1027.31	100	Astro Clock with Photocell Override	OFF	Normal	OK	Normal	Normal
12/31/19 7:40	120.622	0	0	91.40268	1027.31			OFF	Normal	OK	Normal	Normal
12/31/19 7:01	120.078	0.513	61.65	91.36281	1026.52			ON	Normal	OK	Normal	Normal
12/31/19 5:59	119.767	0.785	93.97	91.29987	1025.51	0	Astro Clock with Photocell Override	ON	Normal	OK	Normal	Normal
12/31/19 4:59	119.951	0.784	94.04	91.20582	1024.51	0	Astro Clock with Photocell Override	ON	Normal	OK	Normal	Normal
12/31/19 3:59	120.492	0.781	94.03	91.11177	1023.51	0	Astro Clock with Photocell Override	ON	Normal	OK	Normal	Normal
12/31/19 2:59	120.603	0.78	94.07	91.01767	1022.51	0	Astro Clock with Photocell Override	ON	Normal	OK	Normal	Normal
12/31/19 1:59	120.669	0.781	94.19	90.92352	1021.51	0	Astro Clock with Photocell Override	ON	Normal	OK	Normal	Normal
12/31/19 0:59	121.021	0.778	94.19	90.82933	1020.51	0	Astro Clock with Photocell Override	ON	Normal	OK	Normal	Normal
12/30/19 23:59	120.955	0.778	94.12	90.73518	1019.51	0	Astro Clock with Photocell Override	ON	Normal	OK	Normal	Normal
12/30/19 22:59	121.239	0.776	94.1	90.64099	1018.51	0	Astro Clock with Photocell Override	ON	Normal	OK	Normal	Normal
12/30/19 21:59	121.154	0.778	94.23	90.54689	1017.51	0	Astro Clock with Photocell Override	ON	Normal	OK	Normal	Normal
12/30/19 20:59	121.131	0.777	94.16	90.4527	1016.51	0	Astro Clock with Photocell Override	ON	Normal	OK	Normal	Normal
12/30/19 19:59	121.237	0.777	94.24	90.35846	1015.51	0	Astro Clock with Photocell Override	ON	Normal	OK	Normal	Normal
...												
11/18/19 23:58	120.977	0.505	61.11	33.94016	379.07	50	Mixed Mode	ON	Normal	OK	Normal	Normal
11/18/19 22:58	120.966	0.505	61.1	33.87922	378.07	50	Mixed Mode	ON	Normal	OK	Normal	Normal
11/18/19 21:58	120.969	0.507	61.27	33.8182	377.07	50	Mixed Mode	ON	Normal	OK	Normal	Normal
11/18/19 20:58	120.424	0.51	61.36	33.75703	376.07	50	Mixed Mode	ON	Normal	OK	Normal	Normal
11/18/19 19:58	120.449	0.508	61.22	33.69587	375.07	50	Mixed Mode	ON	Normal	OK	Normal	Normal
11/18/19 18:58	120.527	0.509	61.31	33.63475	374.07	50	Mixed Mode	ON	Normal	OK	Normal	Normal
11/18/19 17:30	120.276	0.51	61.39	33.54508	372.39	50	Mixed Mode	ON	Normal	OK	Normal	Normal

Figure 5 – SLC Number: 27016

The photocontrols were installed on luminaries that have a “nominal” power rating of 92W which is different from the maximum or “rated” power. Thus, there can be a small plus or minus variation in nominal power rating.

There is a reduction in power (watts). For SLC number 23853 in **Figure 4**, the average reduction in power (watt) is around 35 percent. For SLC number 27015 in **Figure 5**, the average reduction in power (watt) is around 35 percent. As illustrated by the charts, 50 percent dimming does not equate to 50 percent reduction in light output.

Figure 6 shows a graphical representation of the data presented in **Figure 4** for SLC number 23853. One can see the reduction correlation between dimming and watts in **Figure 6**.

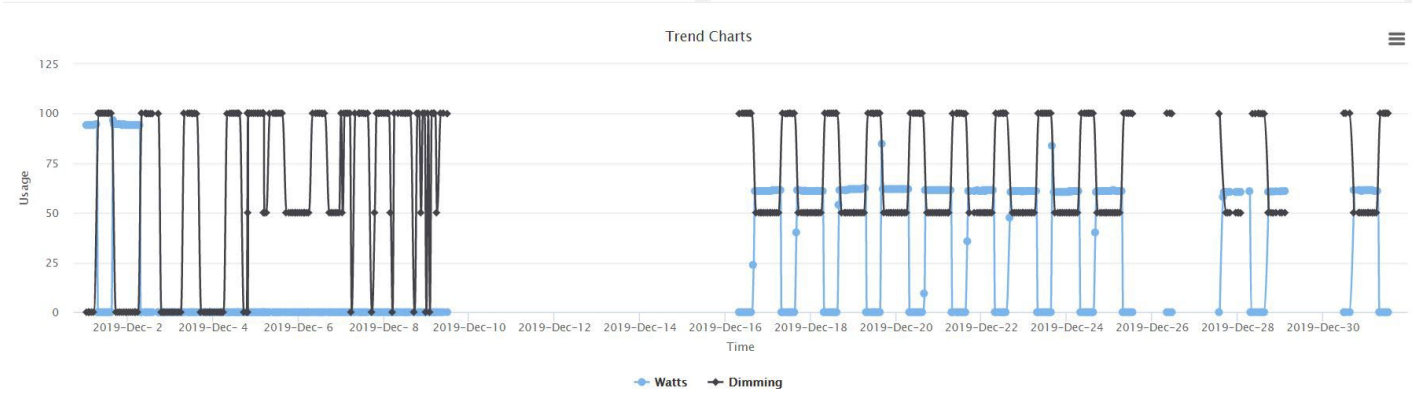

Figure 6 – Trend Chart, SLC Number: 23853

Figure 7 show a graphical representation of the data presented in **Figure 5** for SLC number 27016. One can see the reduction correlation between dimming and watts in **Figure 7**.

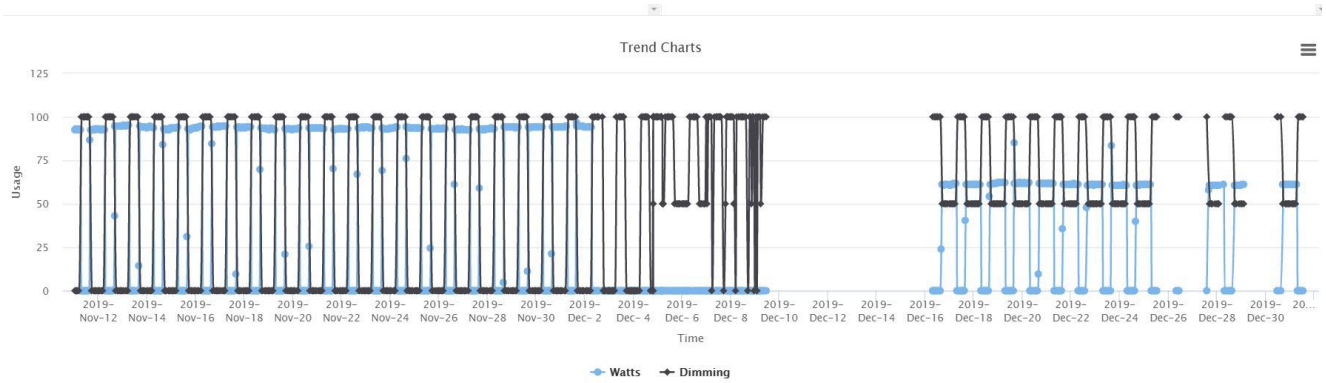

Figure 7 – Trend Chart, SLC Number: 27016

8.0 Troubleshoot

As with any device, failure can happen. There are several ways to be able to troubleshoot the technology. The main two troubleshooting techniques revolve around a gateway communication fault and luminaire/SLC driver. Communication fault can happen when the gateway is not receiving commands from the LightingGale software or when the gateway is not able to reach or send the signal over to the SLC(s). A driver fault can also occur and that is usually due to a poor wiring connection. Low voltage and current can result due to poor wiring connections. Both these faults can be monitored through the software. **Figure 8** demonstrates a scenario where some of the SLCs are not receiving enough voltage. As one can see, the lamp status is off (red) due to not receiving enough voltage. One can solve this issue by checking wiring connections and driver condition. The different columns in **Figure 8** are Lamp Status (LS), Lamp Communication (LC), Communication (C), Driver (D), Tilt, and Volt. The tilt function is used for SLCs that are equipped with motion sensors.

SLC#	Name	Updated	LS	LC	C	D	Tilt	Volt
23853	23853	12/05/2019 04:58:58						49.927
23935	23935	12/05/2019 04:58:32						120.422
24149	24149	12/05/2019 04:58:59						49.919
24228	24228	12/05/2019 04:58:59						49.864
27010	27010	12/05/2019 04:58:24						120.779
27015	27015	12/05/2019 04:59:21						117.601
27016	27016	12/05/2019 04:58:53						117.654
27020	27020	12/05/2019 04:59:00						49.826
27021	27021	12/05/2019 04:58:59						49.743
27023	27023	12/05/2019 04:58:37						117.355

Figure 8 – Device Conditions

The user can also troubleshoot a driver fault through the software by resetting SLC trip. **Figure 9** shows the command to reset the SLC trip. When the SLC is first connected on the LED fixture and powered completely on at 0 percent dimming, the threshold value of steady wattage is calculated and stored in the memory of the SLC. Thus, when actual current flowing in the fixture circuit is less than threshold value, the SLC observes the LED driver trip. Resetting the SLC trip can help solve a driver fault.

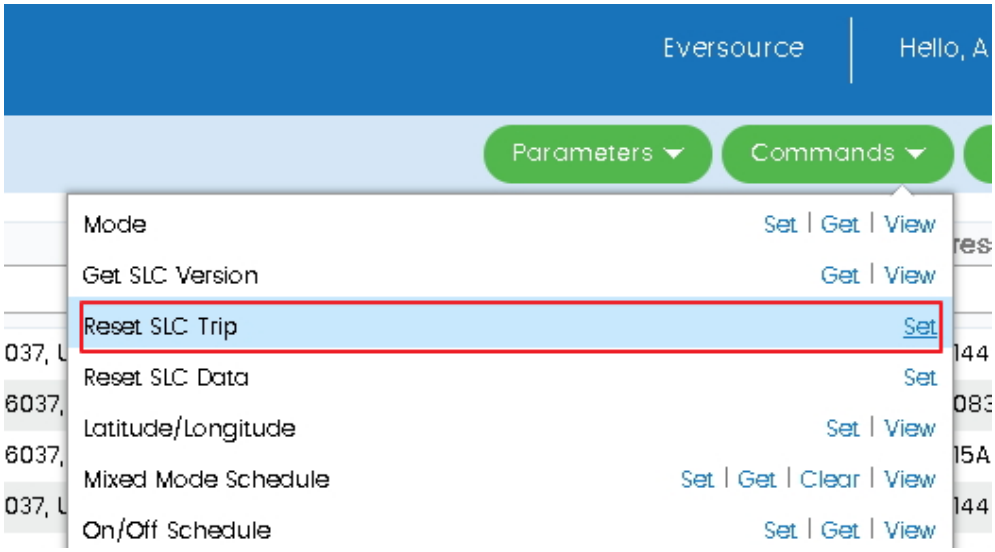

Figure 9 – Reset Command

9.0 Risk and Stakeholder Engagement

Safety and liability are two very important variables to consider. Integrating controls into streetlights offers benefits but also raises safety and liability concerns. Lower light levels and/or no lighting due to photocontrols and/or wireless gateways malfunctions could lead to accidents, injuries, and other public safety concerns. Municipalities must also carefully weigh the risks of Cyber concerns against potential cost savings.

Stakeholder Engagement is also an important factor, to collaborate with other organizations facing similar situations. Conversations with stakeholders, such as the Connecticut Department of Transportation (CDOT), have taken place. CDOT currently does not have plans to implement dimming controls for their roadway lighting. Further collaboration with CDOT on a dimming project could be prudent. Understanding their viewpoints and addressing any reservations about dimmable control implementation is essential.

10.0 Summary

This pilot was conducted with 10 SLCs and one cellular gateway on LED luminaires and not on a large scale of 500+ SLCs with multiple gateways. The pilot duration was around 5 months and conducted on LED streetlight luminaires located at the entrance driveway to the Eversource

Energy building in Berlin, Connecticut. The installation of both the gateway and the controllers was relatively simple as the controllers fit existing NEMA receptacles on LED fixtures and the software also allowed the user the capability of monitoring and sending commands at any time with capability to set schedules and other functionalities. In addition, the software can measure various parameters and can be exported in a graphical visual or into an Excel document. Some parameters include voltage, current, burn hours, and watts.

While the pilot demonstrated the gateway receives the command(s) from the user-end through the software and send(s) them to all or a specified group of controllers for functionality the decision to integrate dimmable streetlight controls involves considerations related to public safety, Cybersecurity, tariff development, cost savings, and technological advancements. It's important to note that many of the streetlights today are not owned or operated by Eversource. Aside from the administration and tariff changes that would be required and demonstrating the ability to successfully control streetlight lumen output, the concern around public safety is the highest risk. Given the liability and potential risk for public safety Eversource does not recommend offering dimmable LED lighting.