Sustainability in Lighting Equipment Reuse

CASE: TKU Airport

LED Retrofit, Case Turku

CCR controlled LED retrofit into existing halogen fixtures and guidance signs

Reusing also existing secondary transformers and AGL cabling.

Over 90 % energy savings, measured from the input of the CCR.

Introduction of AGL Technologies

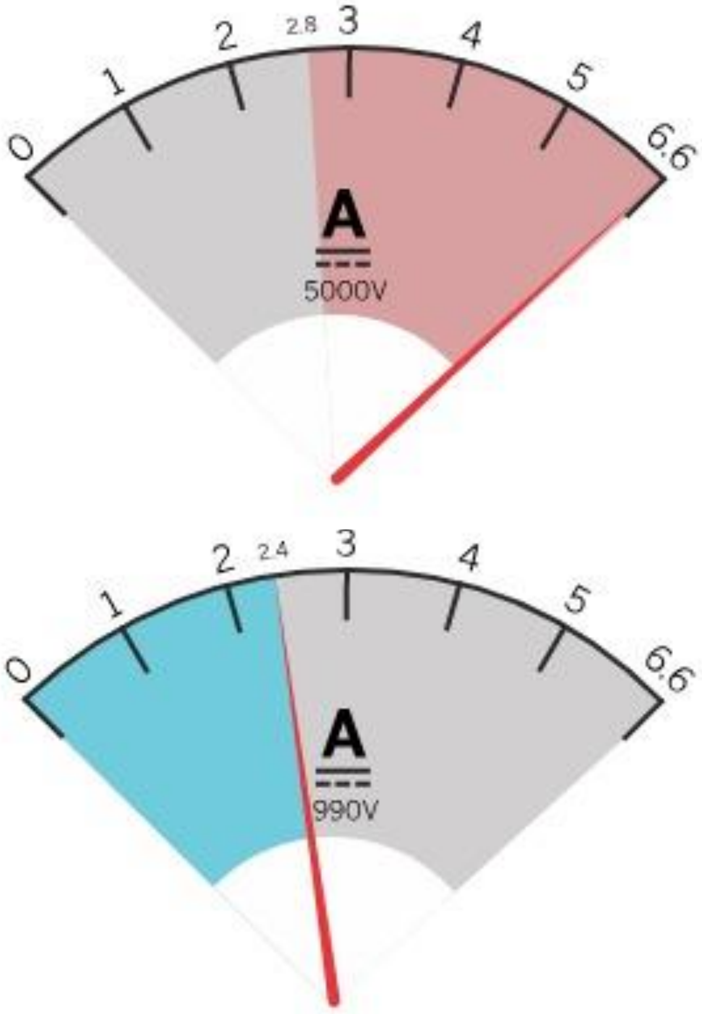
6.6 A HALOGEN	6.6 A LED	INFORMATION CONTROLLED LED	CCR CONTROLLED LED
Series circuit current = Halogen filament current	Series circuit current ≠ LED component current	Series circuit current ≠ LED component current	Series circuit current = LED component current

Constant current series circuits with LED

No power control within fixtures

Replacing halogen currents with LED currents, and halogen bulbs with passive LED bulbs.

The only difference between halogen systems and a CCR controlled LED-current: amplitude, and possibly waveform



Direct control of LED current with CCR

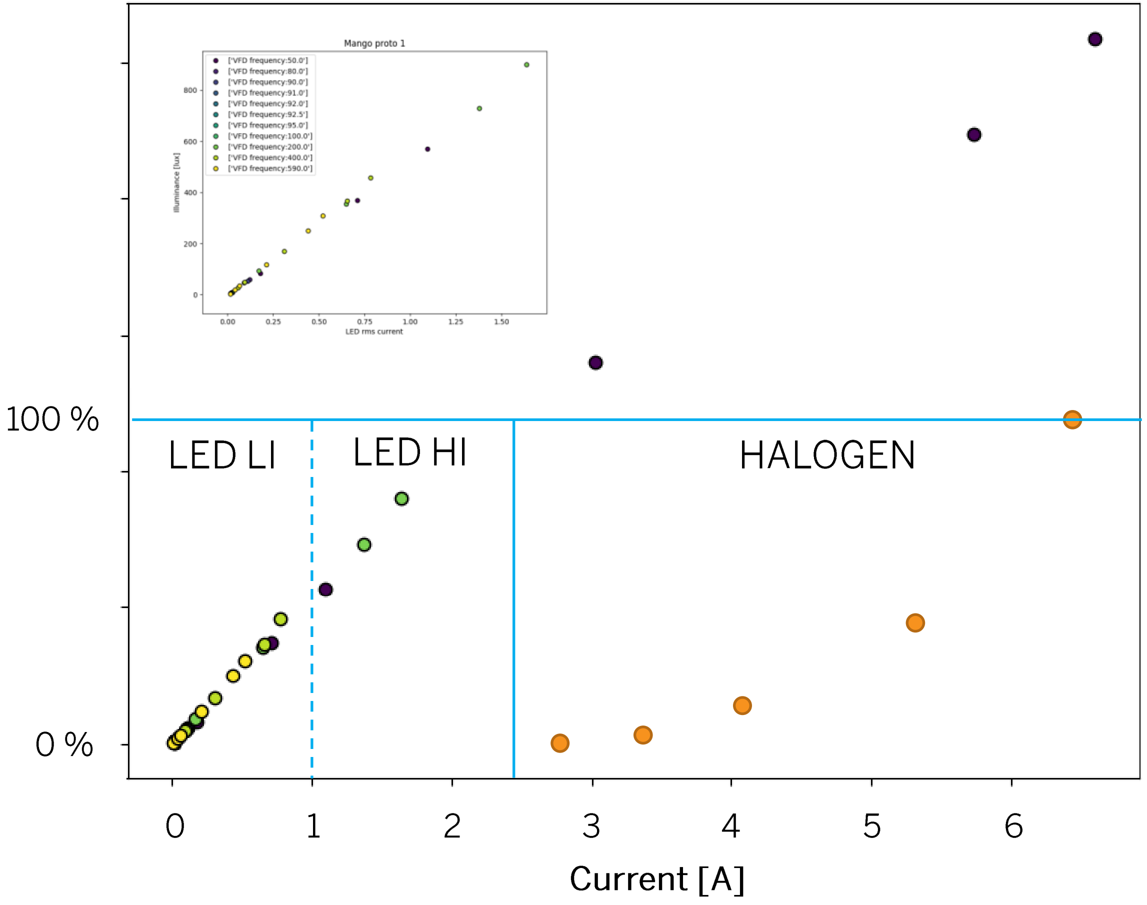
LED luminous response is linear

1 % luminous output requires 1 % current

Native LED currents typically max:

- < 3 Adc (high intensity)
- < 1 Adc (low intensity)

Response measurement from AGL setup



Research based development

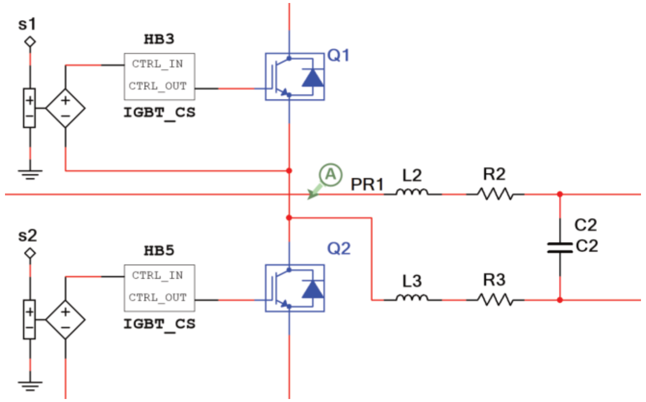
Numerical analyses with extensive computational models (SPICE)

Detailed power supply model (CCR)

Adjustable cable models

Accurate transformer models

Detailed load models




```
ax.plot_surface(X, Y, Z, cmap=cm.coolwarm, alpha=None)
plt.title('AGL ' + km_selection + ' km, modified filter (2017-08-18)')
ax.set_xlabel(x_label_text)
ax.set_ylabel(y_label_text)
ax.set_zlabel('Near LED Current [Arms]')
#%%
km_selection = '3'
zvar = MDrms.loc['I(I_Main)'] - MDrms.loc['I(I_near_LED)']
x = zvar.loc[km_selection].columns.astype(float)
x_label_text = zvar.loc[km_selection].columns.name
y = zvar.loc[km_selection].index.astype(float)
y_label_text = zvar.loc[km_selection].index.name
X, Y = np.meshgrid(x, y)
Z = zvar.loc[km_selection]
fig = plt.figure()
ax = fig.add_subplot(111, projection='3d')
ax.plot_surface(X, Y, Z, cmap=cm.coolwarm, alpha=None)
plt.title('AGL ' + km_selection + ' km, modified filter (2017-08-18)')
ax.set_xlabel(x_label_text)
ax.set_ylabel(y_label_text)
ax.set_zlabel('Main circuit current - Near LED Current [Arms]')
#%%
km_selection = '3'
zvar = (MDrms.loc['I(I_Main)'] - MDrms.loc['I(I_near_LED)'])/MDrms.loc['I(I_Main)']
x = zvar.loc[km_selection].columns.astype(float)
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#%%
km_selection = '3'
zvar = (MDrms.loc['I(I_Far_LED)'] - MDrms.loc['I(I_near_LED)'])/MDrms.loc['I(I_Main)']
x = zvar.loc[km_selection].columns.astype(float)
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ax.plot_surface(X, Y, Z, cmap=cm.coolwarm, alpha=None)
plt.title('AGL ' + km_selection + ' km, modified filter (2017-08-18)')
ax.set_xlabel(x_label_text)
ax.set_ylabel(y_label_text)
ax.set_zlabel('(Far LED current - Near LED Current) / Main current [Arms]')
#%%
fig = plt.figure()
ax = fig.add_subplot(111)
cc_list = ['0', '9', '27']
signal = 'V(Main)'

cc0 = []
cc9 = []
cc27 = []
cc = cc_list[0]
for freq in freqlist: cc0.append(MDrms[cc, freq, signal])
cc = cc_list[1]
for freq in freqlist: cc9.append(MDrms[cc, freq, signal])
cc = cc_list[2]
for freq in freqlist: cc27.append(MDrms[cc, freq, signal])
```

Stability through amplitude, frequency, and waveform control

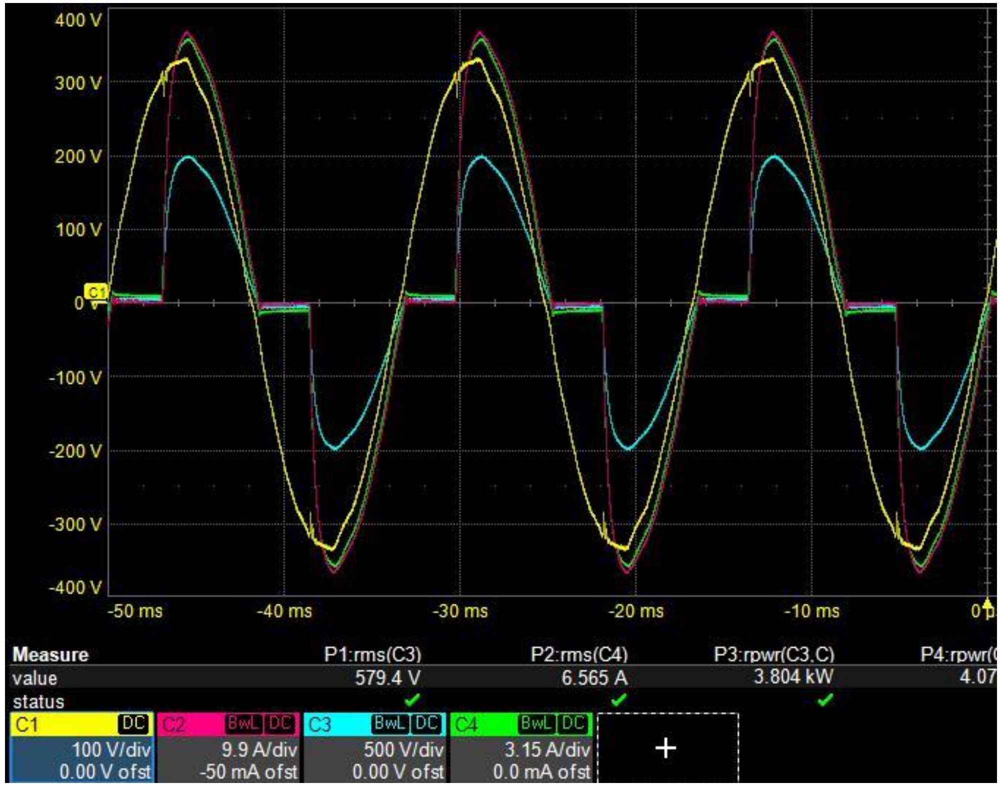
Standard50/60Hz sinusoidal current is good for 2.8 – 6.6 Arms currents.

Low current applications can benefit from higher frequencies and modified waveforms.

Field tests conducted with fundamental frequencies between 50 and 599 Hz.

Modifed waveforms may also be used for improved power transfer and light quality.

Low currents can be made 6.6 Arms cable and transformer compatible.



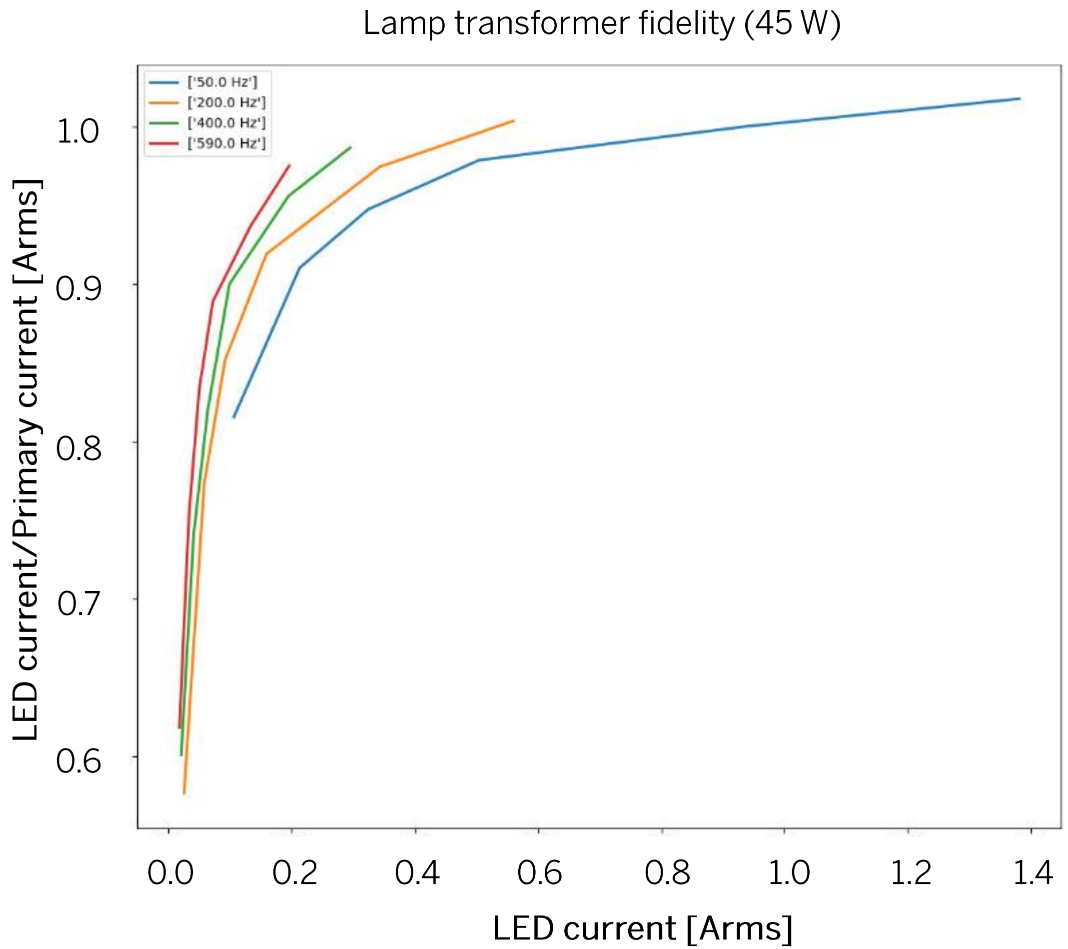
Lamp transformer compatibility

With low current, modified waveforms and higher fundamental frequencies can be used to improve lamp transformer fidelity.

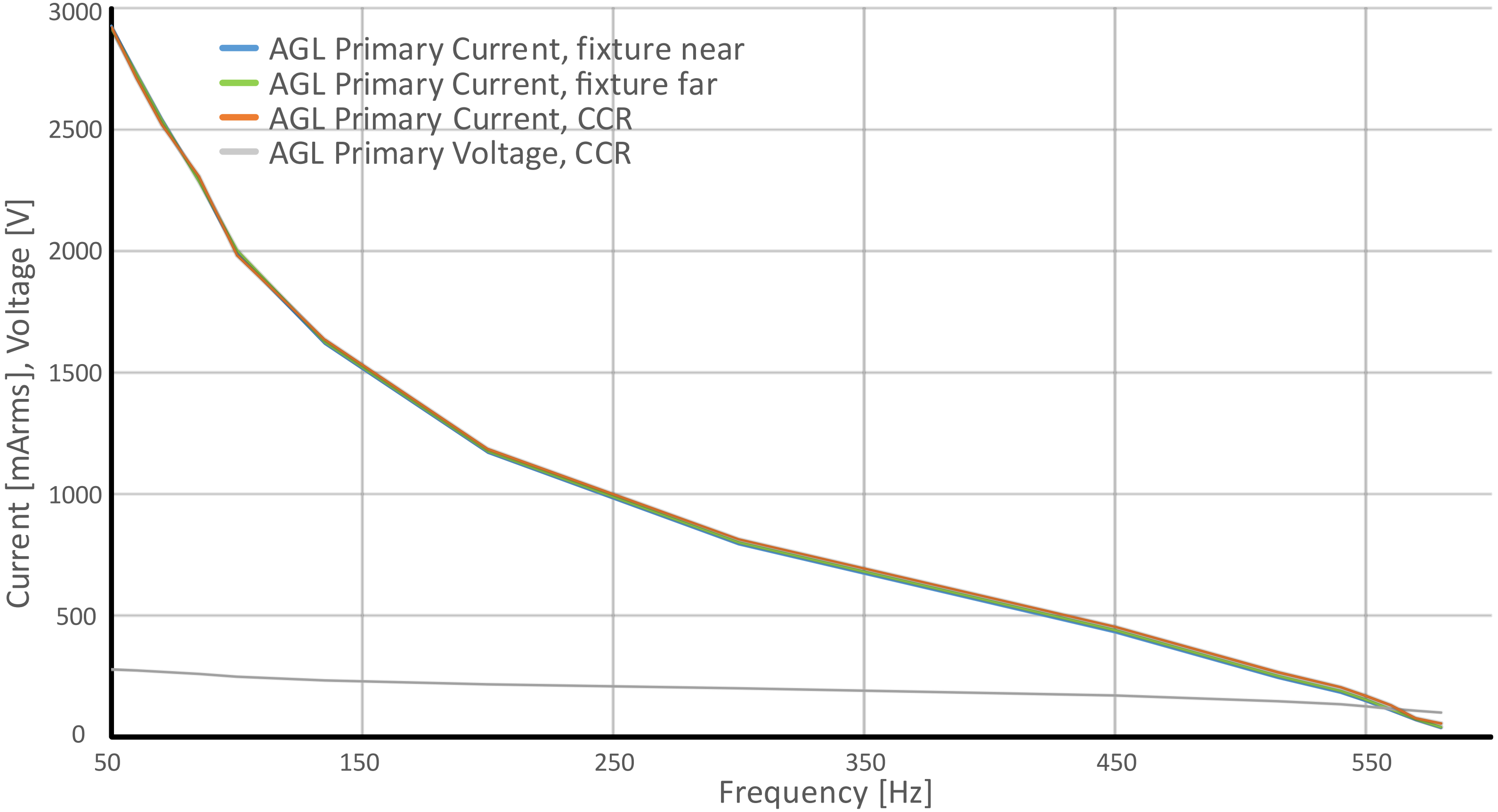
Lower frequencies are used for higher currents

Series circuit cabling affects parameter choices

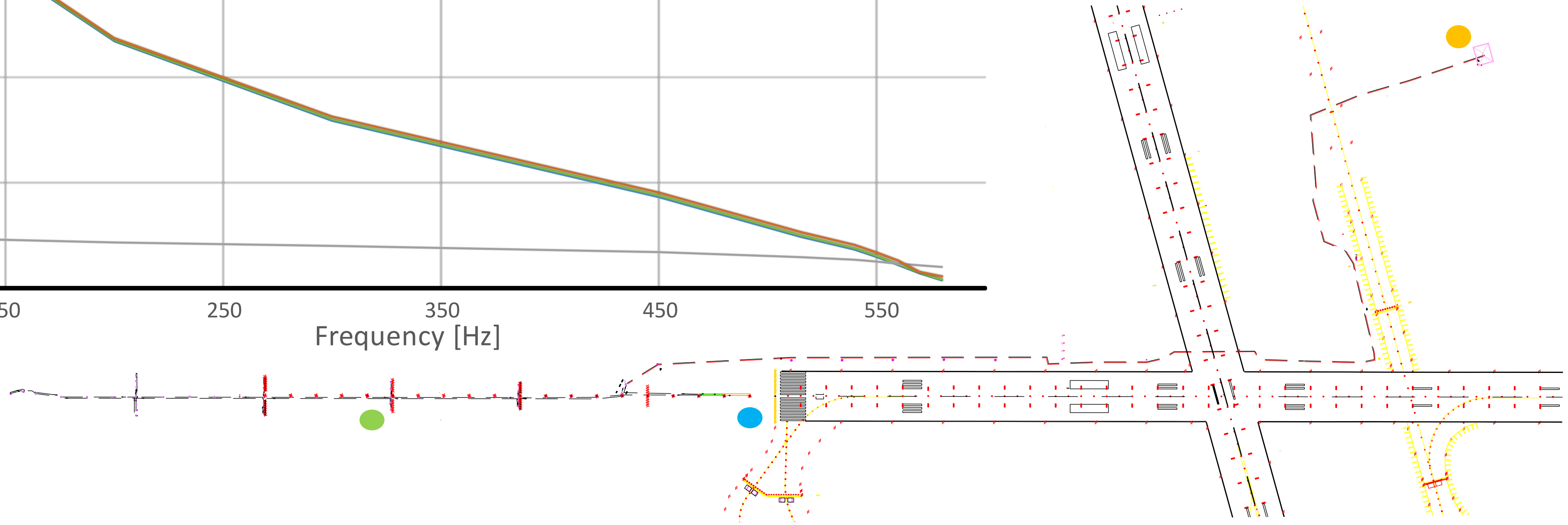
A (low current) CCR can be used for automated circuit analysis and parameter selection.



Current stability with CCR controlled LEDs



LI Approach
54 CCR-controlled LEDs
5 km primary circuit
5 kV Primary cable



Turku Airfield Upgrade (TKU/EFTU)

Original installation

58 taxiway edge fixtures and 9 signs

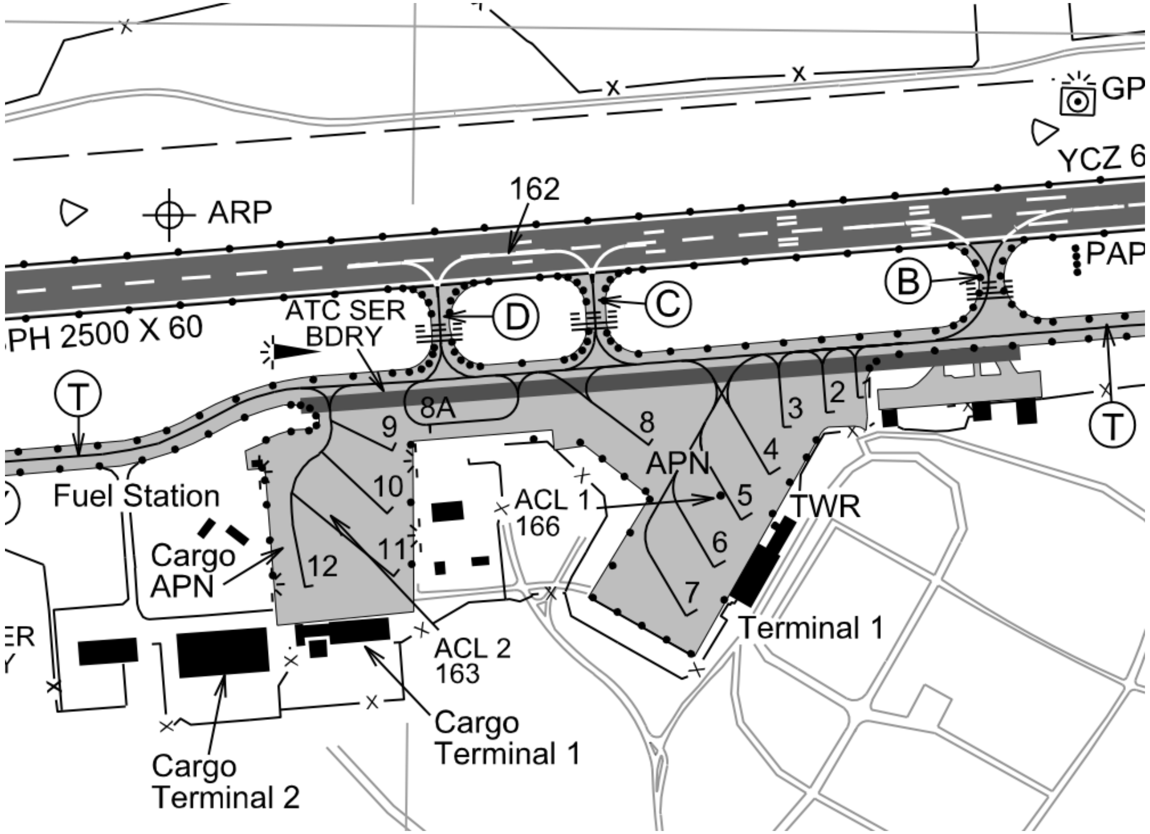
130 PK30d halogen bulbs with 45 Watt nominal power.

LED Upgrade:

130 LED bulbs, 6 Watt nominal power.

Existing fixtures, signs, secondary transfomers and circuit cabling used.

6.6 A CCR replaced with Low current CCR



Turku Airfield Upgrade (TKU/EFTU)

Circuit Details

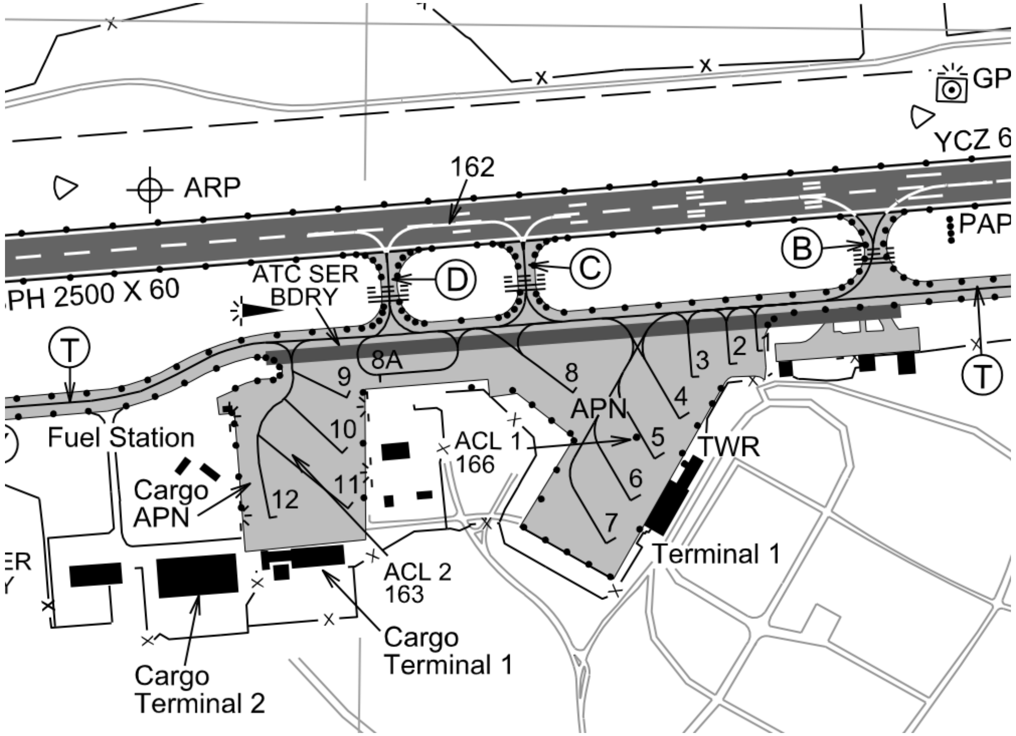
Approximate primary cable length 4.5 km

6 mm^2 primary cable (screened)

2.5 mm^2 secondary cables

58 x 45 W secondary transformer (EFLA KR531)

13 x 200 W and 9 x 150 W transformers for guidance signs (EFLA KR531)



Reusing halogen fixtures in TKU

From 45 watt halogen to 6 W LED

LED bulb mechanically similar to PK30d halogen bulb

Bulb attachment improved with additional strain relief (optional)

Reusing guidance signs in TKU

Old halogen signs upgraded to LED

The 9 signs in TKU retrofit installation were equipped with LED Bulbs.

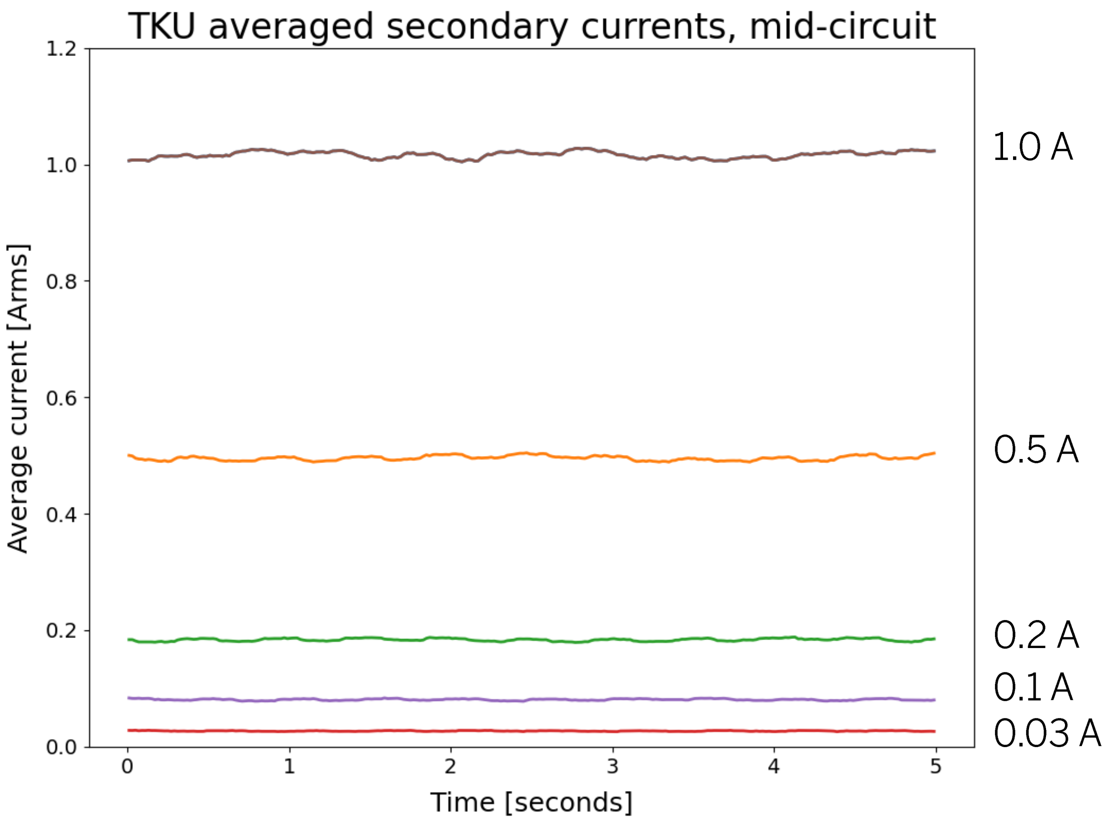
From 4 to 9 bulbs per sign

Halogen bulb nominal power was 45 Watts

LED Bulb nominal power 6 Watts

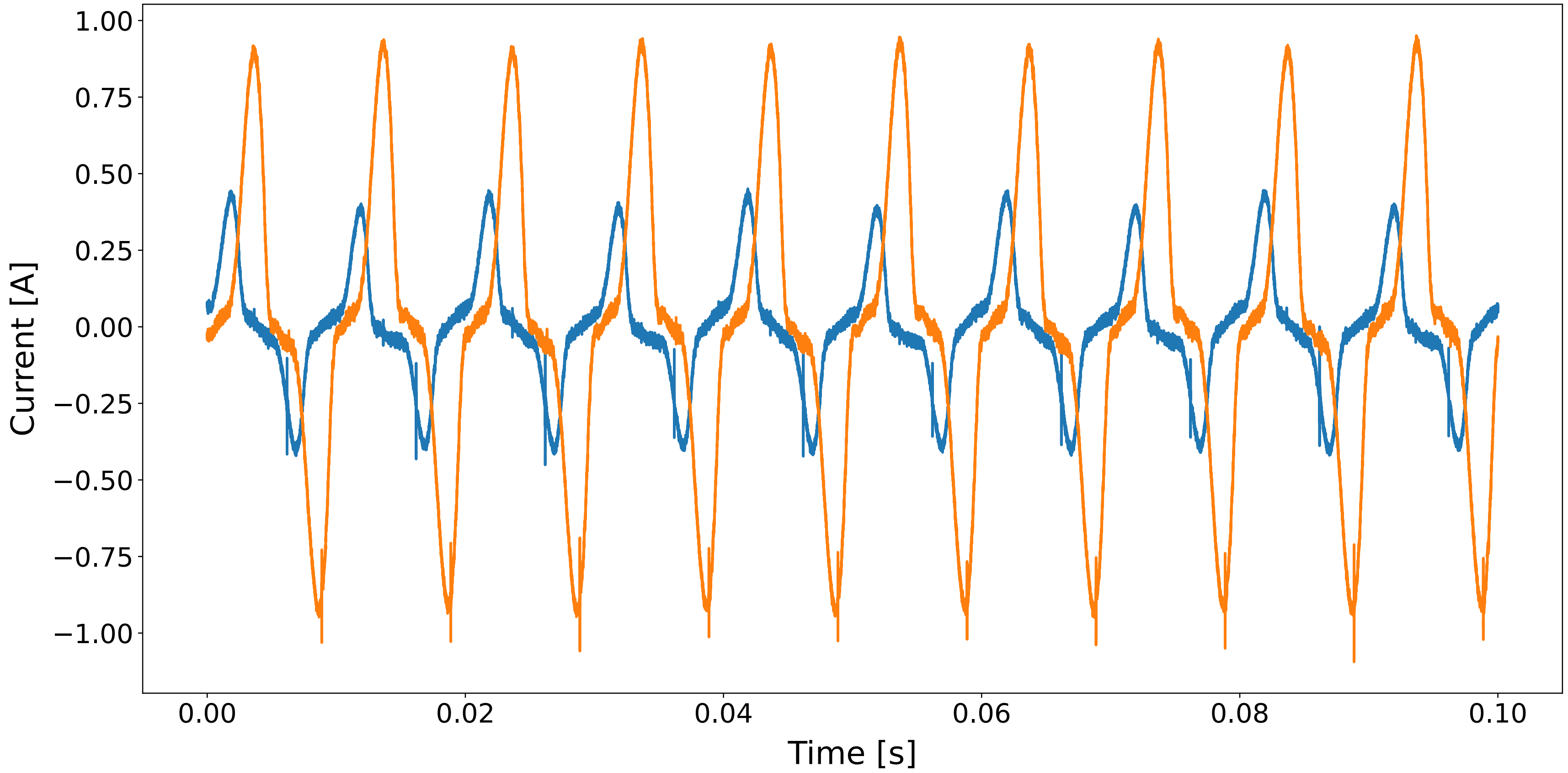
Thermal contact between the sign body and the bulb was improved with redesigned bulb holders.

Averaged secondary current, mid-circuit

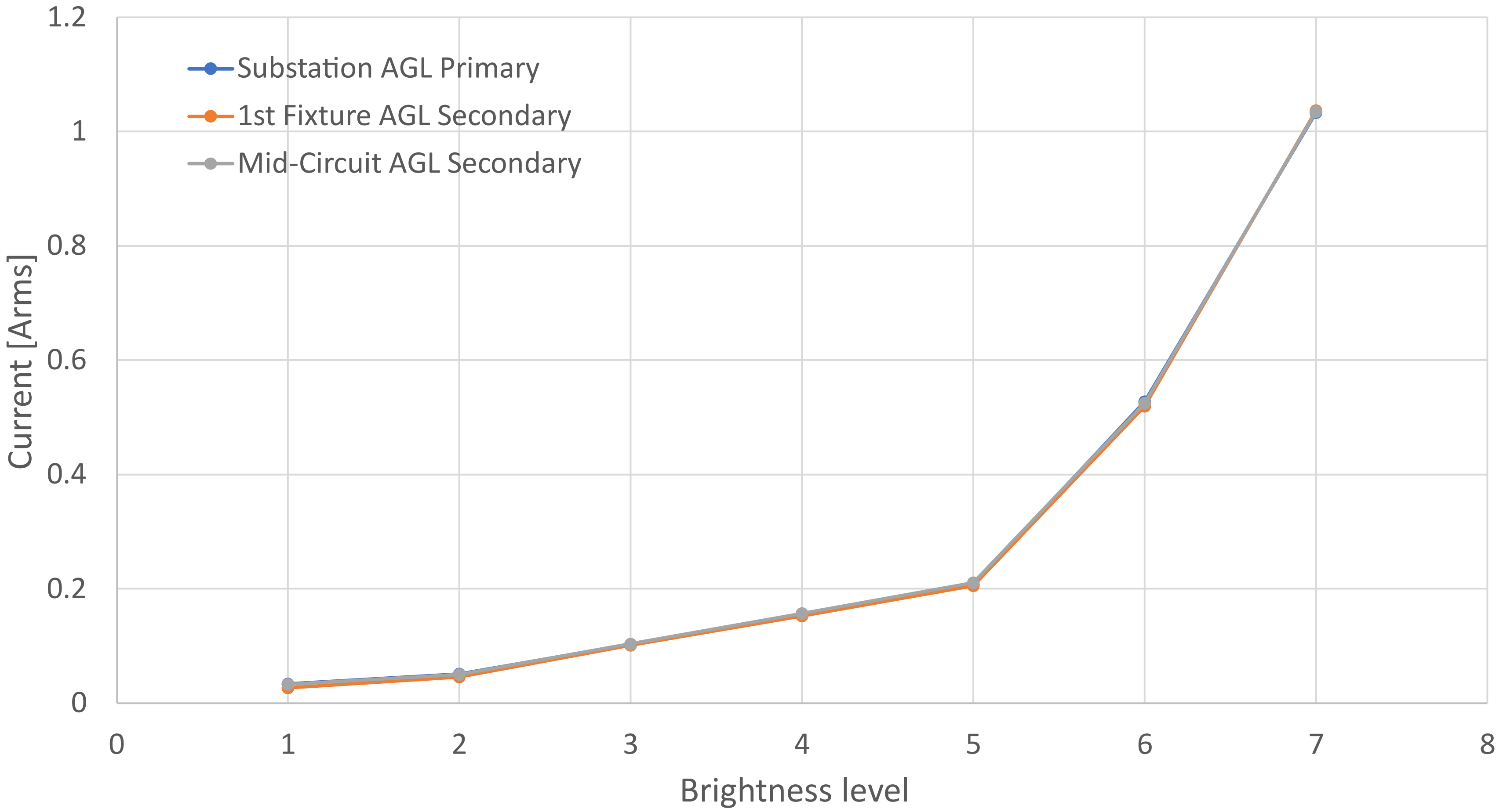


Maximum fluctuations less than 1.2 %

AC-current examples, measured at mid-circuit



Current stability

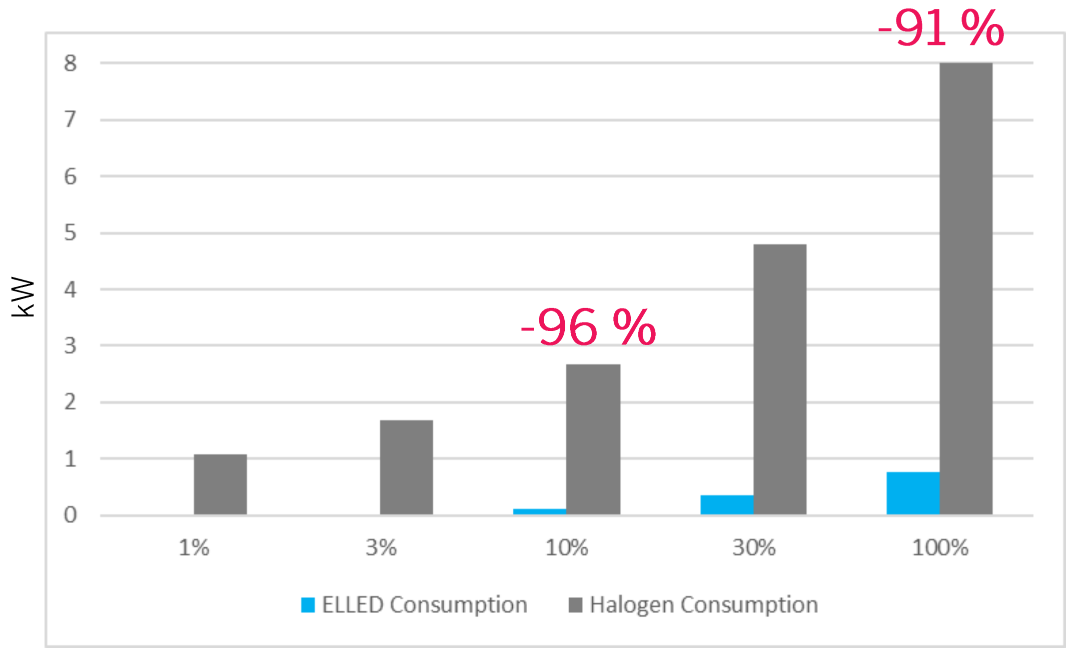


Measured power savings

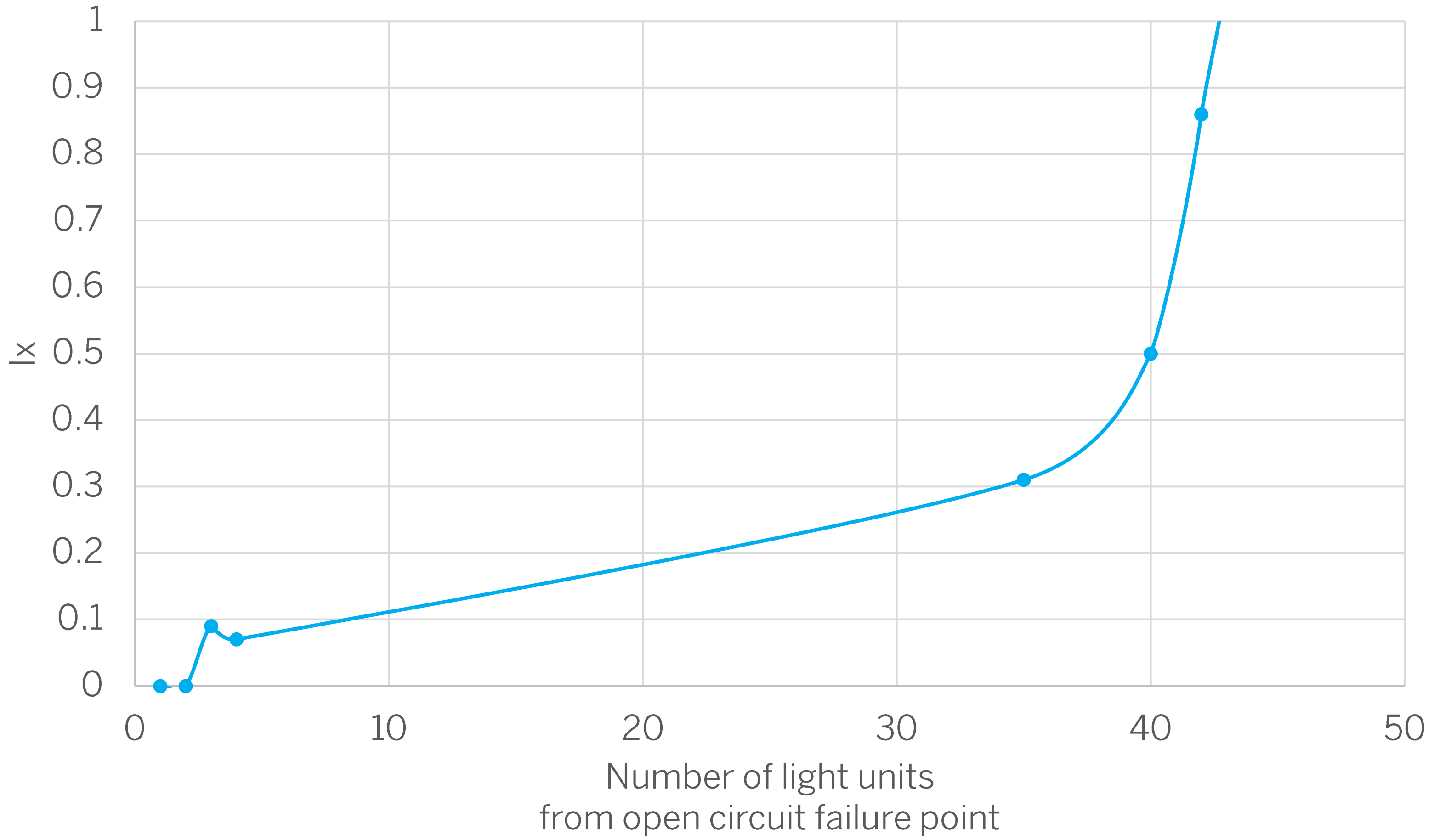
Power measurement from CCR input with FLUKE 435 power energy analyser

STEP - Intensity	Halogen current	LED current
1 – 1 %	2.8 A	0.01 A*
2 – 3 %	3.4 A	0.03 A*
3 – 10 %	4.1 A	0.1 A
4 – 30 %	5.2 A	0.3 A
5 – 100 %	6.4 A	1.0 A

*transformer fidelity to be considered



Open circuit detection with CCR and LED Bulbs



Conclusion

Controlling LED component current directly with the CCR is possible in an AGL installation

Low AGL currents bring substantial energy savings

Long lifetimes expected due to simple passive components within fixtures.

Simple construction allows replicating halogen bulb dimensions

Case Turku introduced, usage cases from other applications also available, e.g. TCL inset lights & LI approach

Technology is not limited to low intensity circuits. Photometrics verified for RWE, TZD, Approach and THR too

ELLEGO low current solution on display in expo