Analyses of Properties of Electronic Ballasts for High Pressure Sodium Lamps and Energy Saving Options by Applications of Electronic Ballasts to Streetlighting

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1 Background

Like for fluorescent lamps, electronic control gear ECOLUM replaces conventional magnetic ballast for discharge lamps – mercury and sodium lamps. ECG combines a function of igniter, choke and compensating capacitor. Ignition and stabilisation of discharge is done in an electrical way at high operational frequency. Such a solution brings a series of benefits:

- Lamp power stabilisation in voltage range 230 V ± 10 %, i.e. 207 – 253 V
- High power factor
- Limitation of harmonics in comparison to conventional ballast and in accordance with limits defined in EN 61 000 – 3 – 2
- Controled ignition current for elimination of eliminuje high current levels at start of cold lamp
- Integrated protection system for disconnection of voltage at missing, damaged, defective or burned lamp
- Warm startup prolonging the lifetime of lamp
- No light flickering when operated at high frequencies
- Dimming option

ECOLUM is one of first ECGs for discharge lamps, available for 80 and 125 W mercury lamps and 70, 100 and 150 W sodium lamps – most common lamps used in public lighting systems. Technical data of ECOLUM electronic ballast are given in tables 1 and 2.

Tab. 1 ECOLUM – types overview

Type	**lamp**	**P (W) normal**	**P (W) dimming**	**I (mA)**	**f (kHz)**
EC-80 Hg/D	Hg 80 W	80	48	350	30
EC-125 Hg/D	Hg 125 W	125	87	540	23
EC-70 Na/D	Na 70 W	70	45	300	30
EC-100 Na/D	Na 100 W	100	63	430	30
EC-150 Na/D	Na 150 W	150	85	660	23

Tab. 2 Technical data of ECOLUM ECG

Range of supply voltage U (V)	185 – 250 V
Range of supply frequency f (Hz)	50 – 60 Hz
Power factor	> 0,98
Operating temperatures	- 20 °C až + 60 °C
Maximum permissible temperature	+ 75 °C
Ingress protection	IP 20

Fig.1 The Ecolum Electronic Control Gear

2 Goals of imvestigation

Research was in its first stage concentrated on analyses of photometric parameters and their behaviour at different operational regimes. Although analyses of electrical and economical properties have been consequently succesfully performed and completed, due to limited space of this paper we only bring to the public results of the first stage. Goals in particular were as follows:

- Measurements of luminous flux and efficacy
- Time chart of luminous flux and efficacy at startup, dimming transition, normal regime restoration
- Measurments of parameters at supply voltage variations
- Measurement of parameters at short-time dropouts

3 Methodology

Workbench for measurement was arranged as shown on Fig. 2 and 3. Luminous flux (and efficacy) has been measured in a photometric integrator, auxiliary electrical instruments used for measurments are specified below.

No.	Instrument	Type, manufacturer, technical data
1	network analyzer	EUROTEST 61557, Metrel
2	voltmeter	Multimeter RTO DMM-3800-21
3	voltage regulator	RA-10, 2 500 VA, 8/10 A, 120/220V, 0 – 250 V, No. 014202
4	A: ECG	ECOLUM EC3-150, Lumtec
	B: CCG	Elektrosvit 5061,
		cos φ = 0,42, igniter Dakor Electric TRZ 11
		for NAV 100 – 250 W, capacitor Tesla 20 μF
5	recording device	
6	chronograph	
7	regime selector	
8	photometric integrator	$\varnothing$ 1,2 m, inner surface $BaSO_4$
9	illuminance meter	Radiolux 111, PRC Krochmann, class A (DIN 5032-7)
		0,001 lx – 36 klx

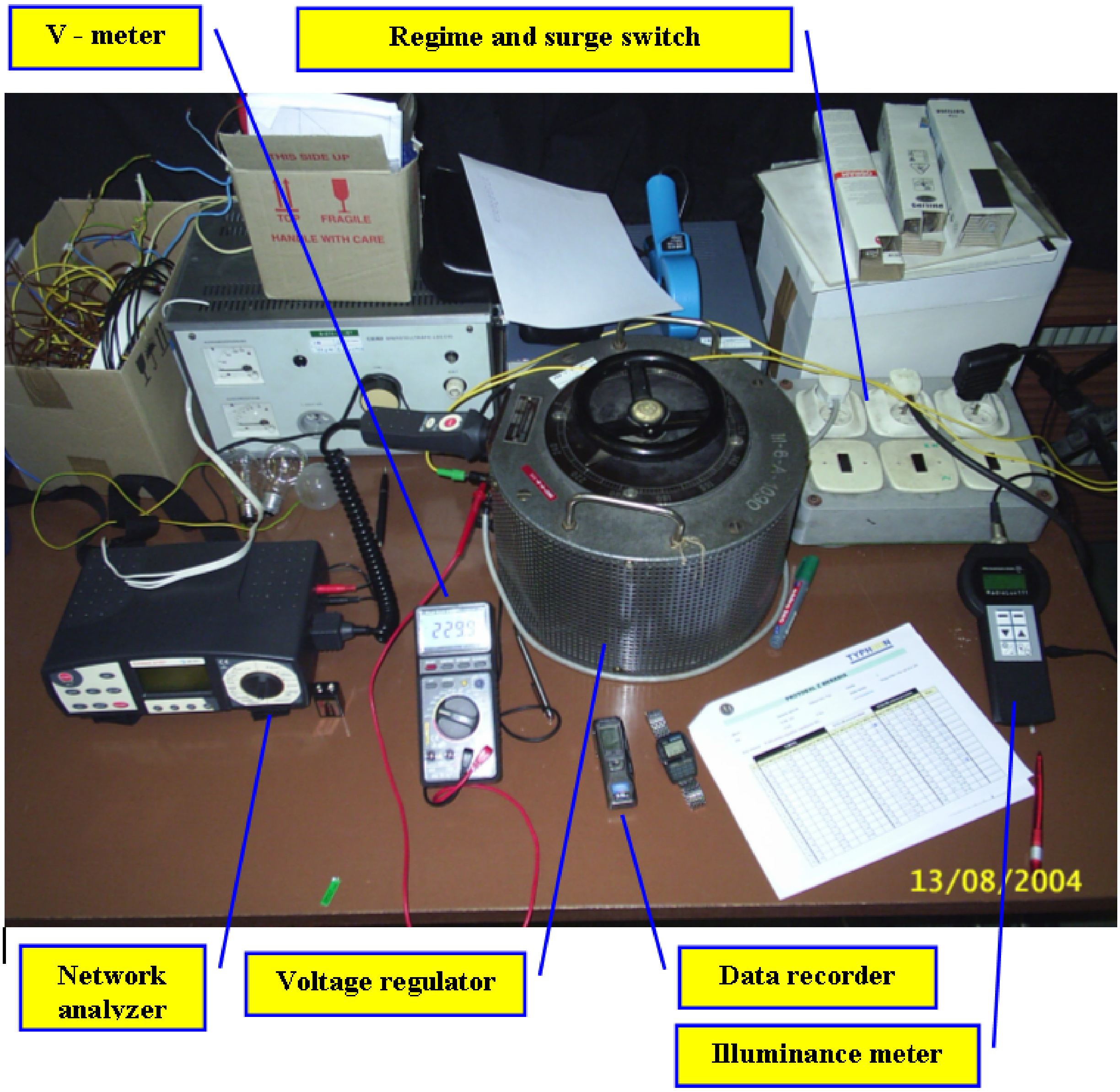

Fig.2 Arrangement of workbench for measurment of ECG ECOLUM

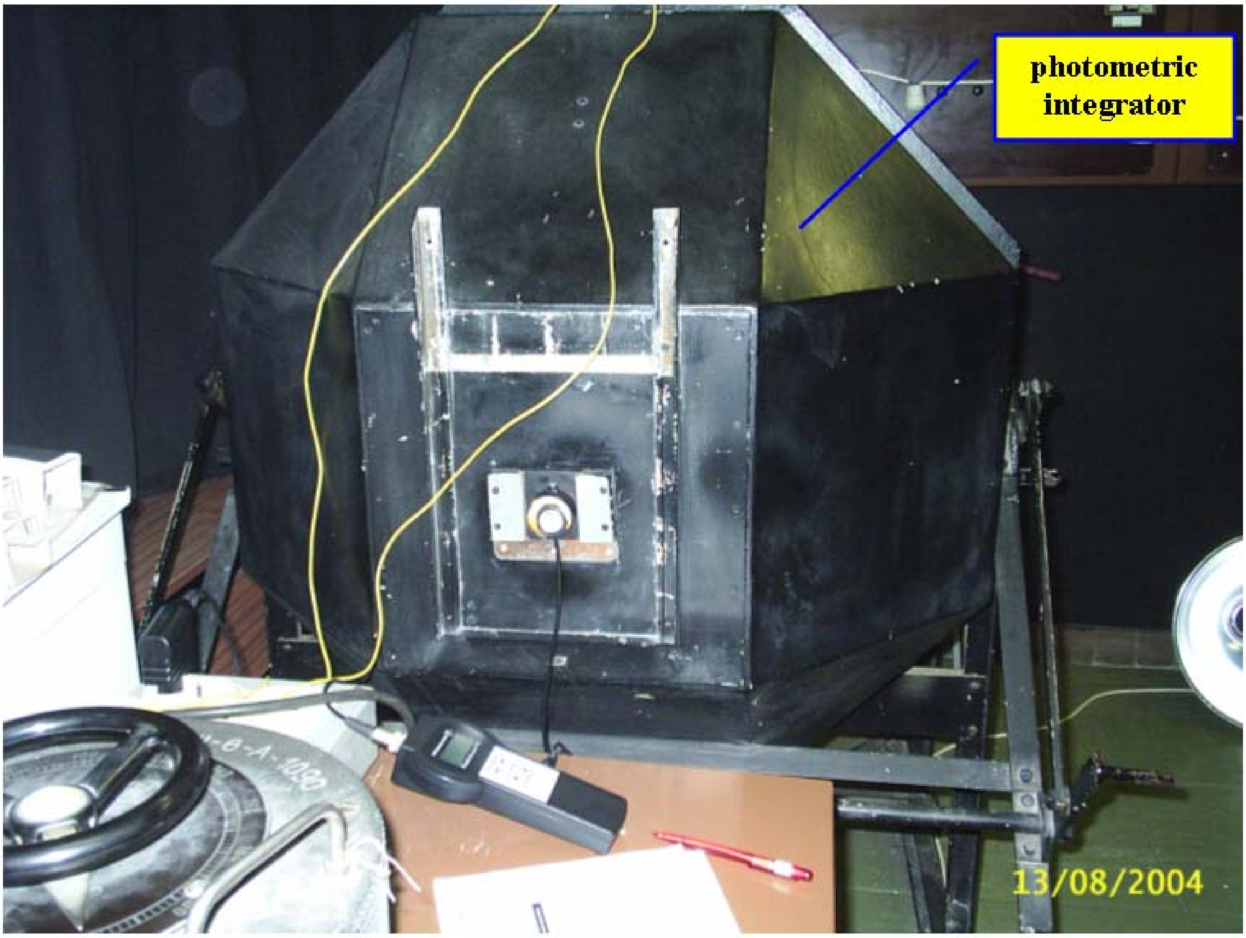

Fig.3 Measurment of luminous flux in photometric integrator

Discharge lamps measured:

1	–	Osram NAV-T Standard 150 W, E 40, 1,8 A, 14 500 lm, 97 lm/W, 2 000 K
2	–	Philips SON-T 150 W Pro, E 40 1,8 A, 15 000 lm, 100 lm/W, 2 000 K
3	–	Philips SON-T 150 W PIA, E 40, 15 000 lm, 100 lm/W, 2 150 K

4 Results and discussion

1. Behaviour of photometric parameters at starting and at transition to reduced power regime

Lamps operated with ECG require less time for startup than when operated with CCG. System wattage for ECG operation is exactly the same as rated – 150 W. For CCG operation it's value is 156 W. Transition times for dimming regime is approximately a half in comparison to startup and time for restoration of normal regime is almost instant and neglectable. In reduced power regime, system power was 82 W. Efficacy decreased from 90 – 100 lm/W (depending on lamp type 1 to 3) down to 50 – 68 lm/W.

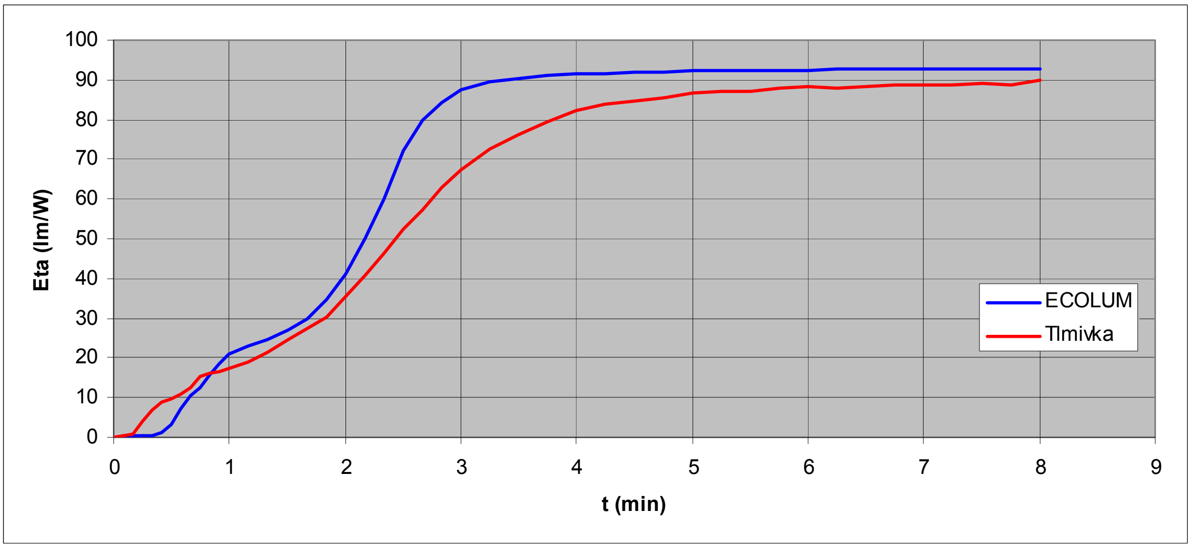

Fig.4 Luminous efficacy at startup

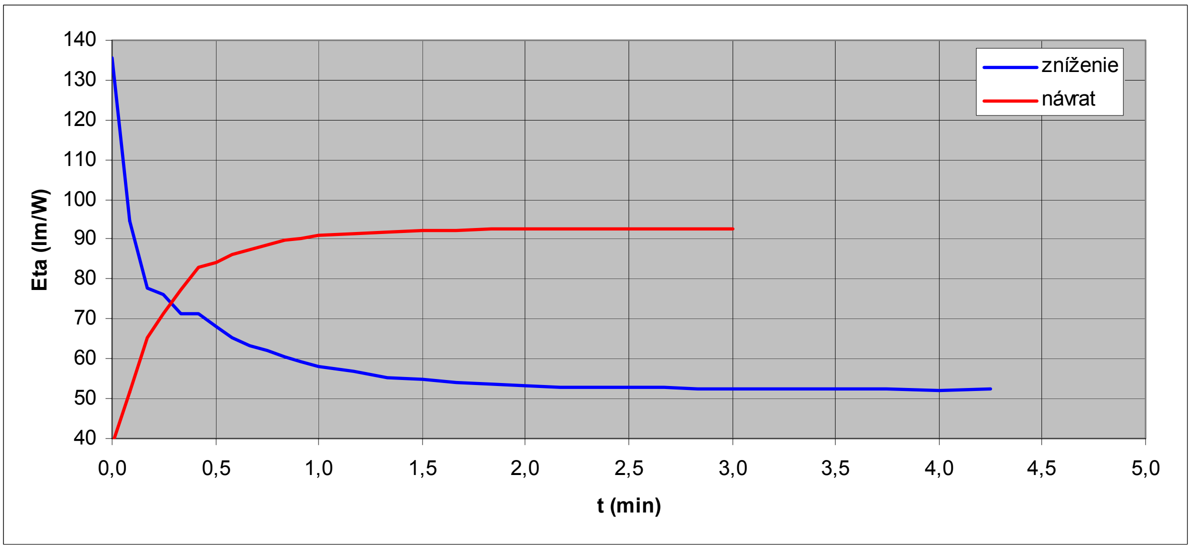

Fig.5 Luminous efficacy at transition into dimming regime and normal regime restoration

2. Behaviour of photometric parameters at supply voltage variations

When operated with ECG ECOLUM, no variations of supply voltage within given range will directly affect to photometric parameters, which are hold to be constant with accuracy approx. 0,1 % (as measured). This applies both for full-power and reduced-power operational modes. Situation with CCG is depicted on Fig. 6, where dependance on voltage is clearly recognizable.

3. Hot restart of lamps at short-time voltage cuts

Time for restart depends on lamp type and generally it is 30 to 45 seconds independently on ECG or CCG operation. After discharge is ignited, startup time for reaching the nominal luminous flux is generally shorter than at normal cold start. Startup begins from the level of about 120 W (20 % below the rated value), luminous flux 65 % below its saturated value and efficacy from 40 lm/W.

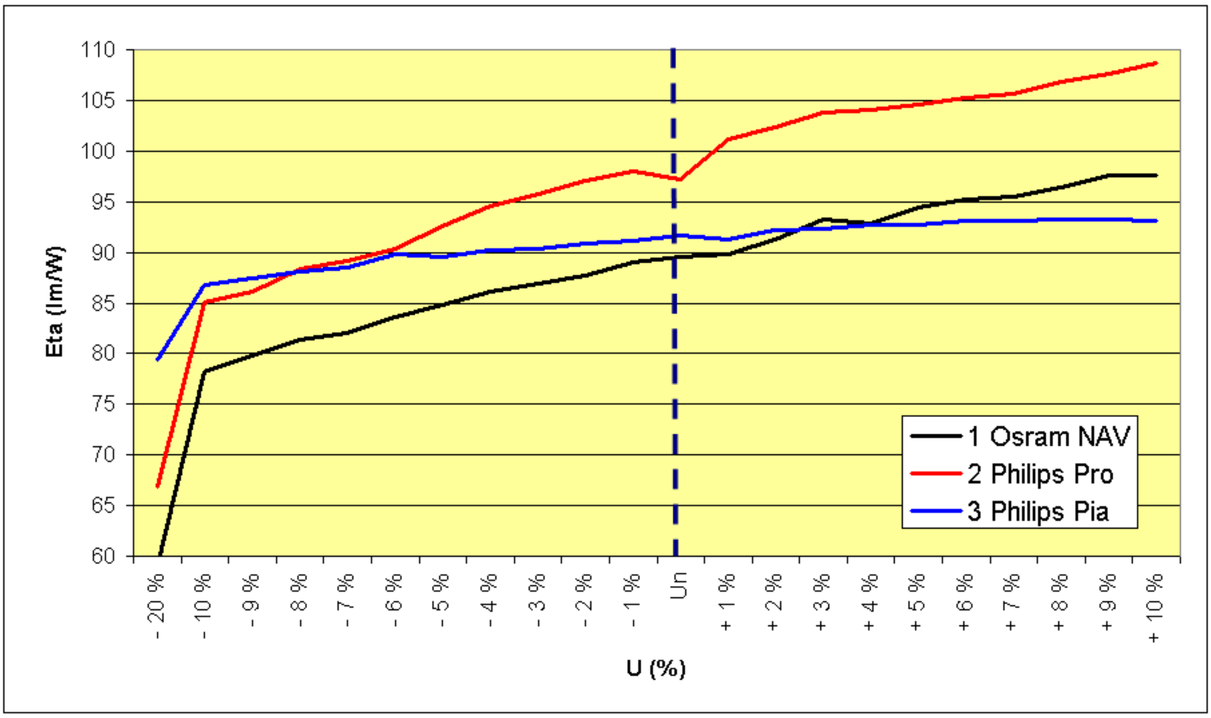

Fig.6 Luminous efficacy at variation of supply voltage

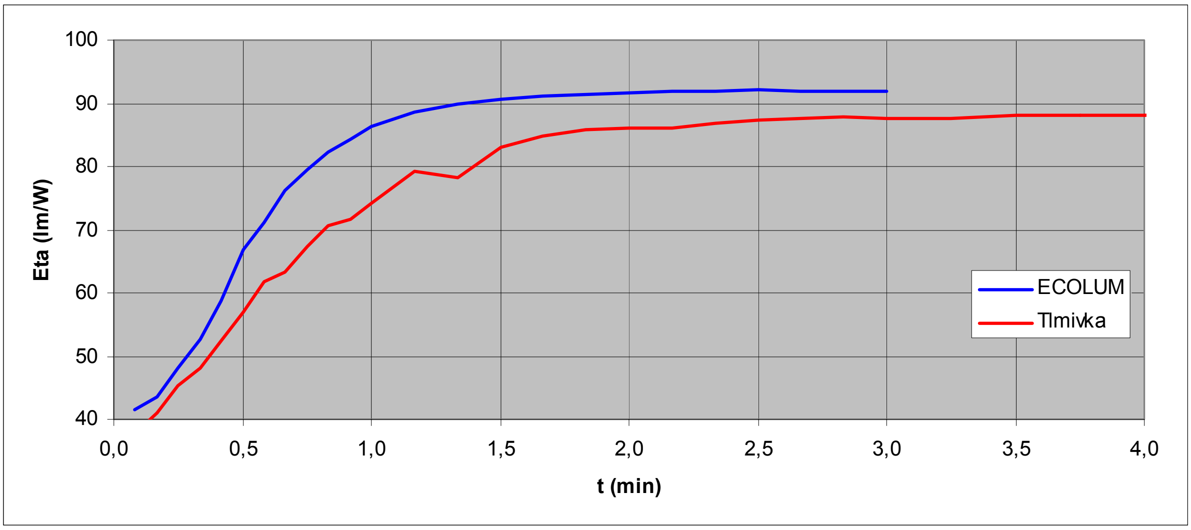

Fig.7 Luminous efficacy at startup after voltage cut

5 Summary

Measurements and consequent analyses showed that the ECOLUM electronic control gear is an efficient, energy-saving and modern tool for energy savings in public lighting:

1. Lamps operated with ECOLUM saturate their electric and lighting parameters incomparable faster. Transitions between regimes of normal and dimmed light are very rapid.
2. Efficacy of the system (lamp + ballast) is higher when operated by ECOLUM in comparison to a common inductive ballast.
3. The ECOLUM control gear stabilizes on constant value both the consuming input power and radiated luminous flux very precisely and independently on the supply power voltage within the investigated range - 20% Un / + 10% Un. Using inductive ballast, input power as well as luminous flux vary with supply voltage.
4. Ignition of discharge after power drop-outs is faster with ECOLUM, mainly at reduced power level. Also stabilisation of electric and lighting parameters are rapid.
5. Operation with ECOLUM is characterized by high power factor, at normal power regime its level was stable at 0,98. Operation with conventional ballast brings worse power factor levels, especially during stabilisation of discharge.
6. ECOLUM protects the lamp against operational overvoltages. Electrical parameters at output of the control gear are separated from its inputs so no influence is transformed to the lamp.
7. Advantages of ECOLUM in comparison to voltage regulators:
   - lighting at reduced power level do not depend on supply voltage (voltage drops, variations, surges)
   - do not require re-construction of power lines
   - do not depend on lamp structure in lighting system
   - it is always passed for a given lamp type
   - input power can be decreased for dimming purposes more than with a regulator
8. Magnetic ballast is a rich source of harmonics which can impact backwards to the supply grid. Contents of harmonics is significantly lower with ECOLUM.
9. Using the electronic control gear ECOLUM, up to 20 – 25 % of electricity bill can be saved and short payback time of investments can be reached.

References
[1] ECOLUM – Technical data and manual of operation.

Acknowledgments
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