Municipal lighting energy saving

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INVESTING IN OUR FUTURE
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Introduction

Municipal lighting energy consumption is mainly met at:

- street lighting
- buildings, monuments and several premises lighting (safe or decoration lighting).

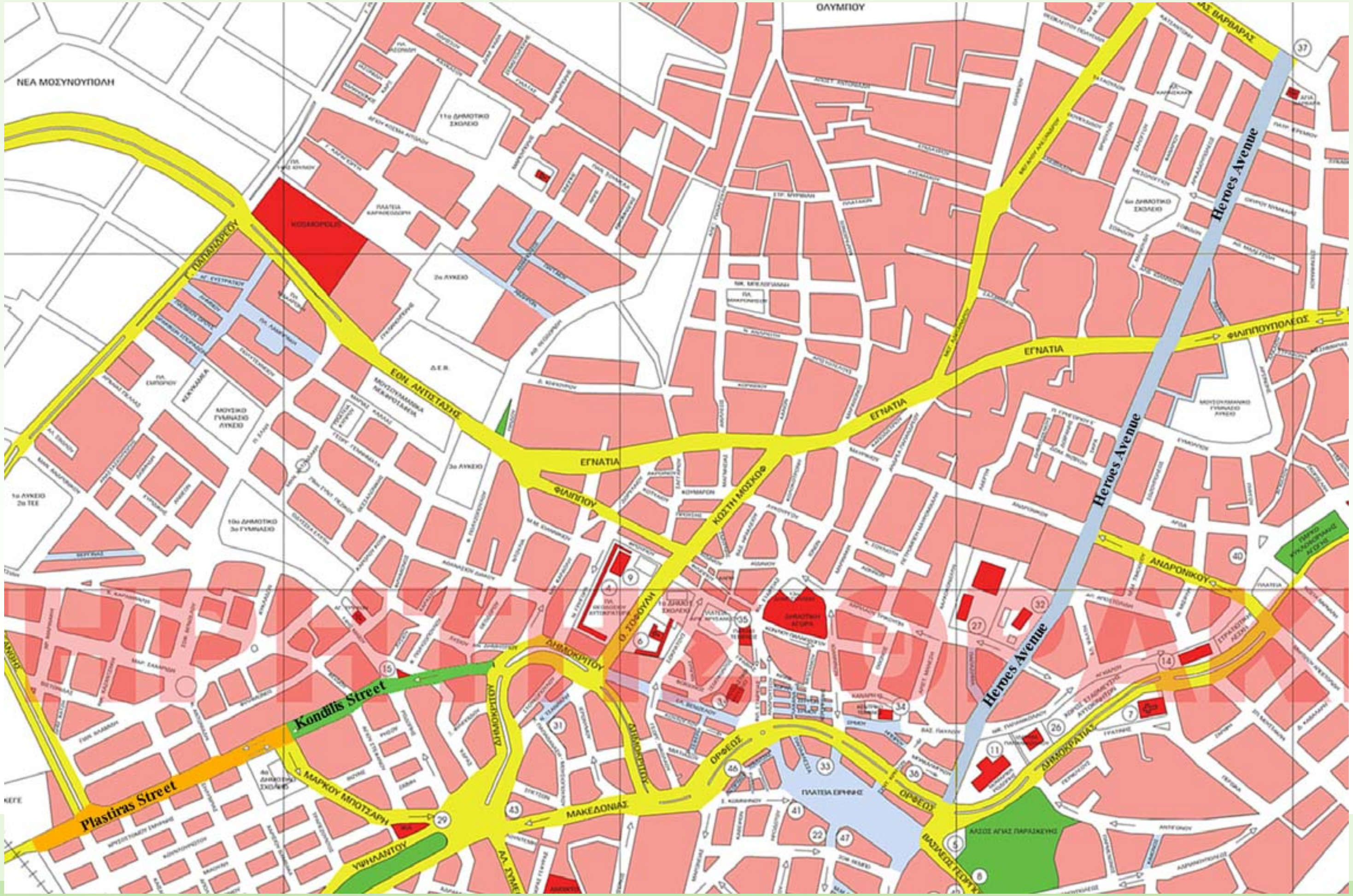
Municipal energy lighting saving can be achieved with the following actions:

- the substitution of high nominal electric power lamps with energy saving lamps of equal luminous flux
- with the automatic monitoring and control of both the lamps’ operational time period and operational power regulation.

Street lighting energy saving case study

- In this presentation a street lighting energy saving case study for the town of Komotini will be presented. The case study is restricted in the following roads of the town:
  - Heroes Avenue
  - Kondilis street
  - Plastiras street.
- The presentation is based on the results of the feasibility study accomplished by Mr. Assariotakis Zacharias, Mechanical Engineer, which was applied for funding by the Municapality of Komotini within the frames of the action «Saving».

Street lighting energy saving case study for the town of Komotini



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ΔΗΜΟΣ ΘΕΡΜΑΪΚΟΥ
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Present status regarding the electricity consumption on the examined roads

Present status on the examined roads

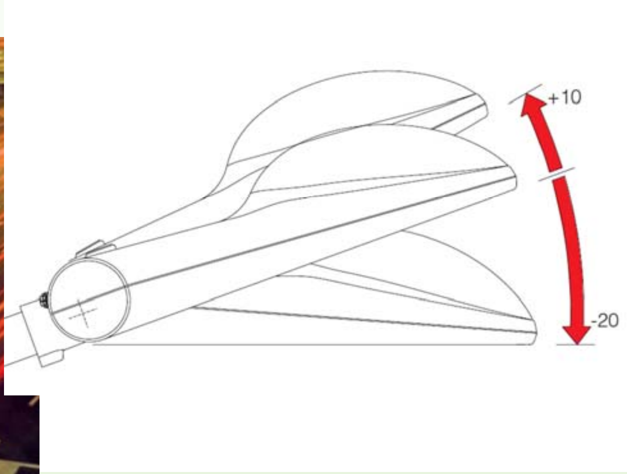
	Heroes Avenu	Kondilis & Plastiras Str,
Road's length (m)	1,270	370 + 420 = 790
Number of lamps	54	33
Mast type	cement	cement
Mast height (m)	9	9
Lamps' distance (m)	21 … 25	21 … 25
Lamps' installation mode	one-side	one-side
Lamps' type and power (W)	MFB 250W (mercury)	MFB 250W (mercury)
Ballast type	magnetic	magnetic
Ballast power (W)	25	25
Lamps' operation management	timer	timer
Pillar position	Heroes Av. & Egnatia Str.	Kondilis & Plastiras Str.

Present status on the examined roads

- The electricity consumption data are presented commonly for the Kondilis and Plastiras streets, since these two streets are provided with electricity from the same pillar.
- Measurements of the illuminance were performed on the examined streets, using an appropriate instrument (Testo 545). The measurements were accomplished on the vertical line from the lamp to the ground, 1m above the ground surface. The measurements' results varied from 3 to 6Lux.
- The required illuminance on the streets depends on the street kind and the area.
- Illuminance decreases with the distance from the light source (lamp) with a rate of approximately 1Lux per m, on the vertical line from the lamp to the ground surface. Measurements were performed on positions with no other light sources present, except the examined lamp.

Present status on the examined roads

- To improve the lighting quality, it is very important to approach high lighting concentration on the desired point, in order to achieve maximum lighting efficiency (lumen/W) and to avoid the disturbing phenomenon of glare.
- The lighting concentration is achieved with the use of the appropriate lighting fixture.



Required lighting illuminance for streets

Street type	Road traffic	Illuminance (lux)
Highway		9
Expressway	High	14
	Medium	12
	Residential area	9
Main street	High	17
	Medium	13
	Residential area	9
Collective street	High	12
	Medium	9
	Residential area	6
Local street	High	9
	Medium	7
	Residential area	4

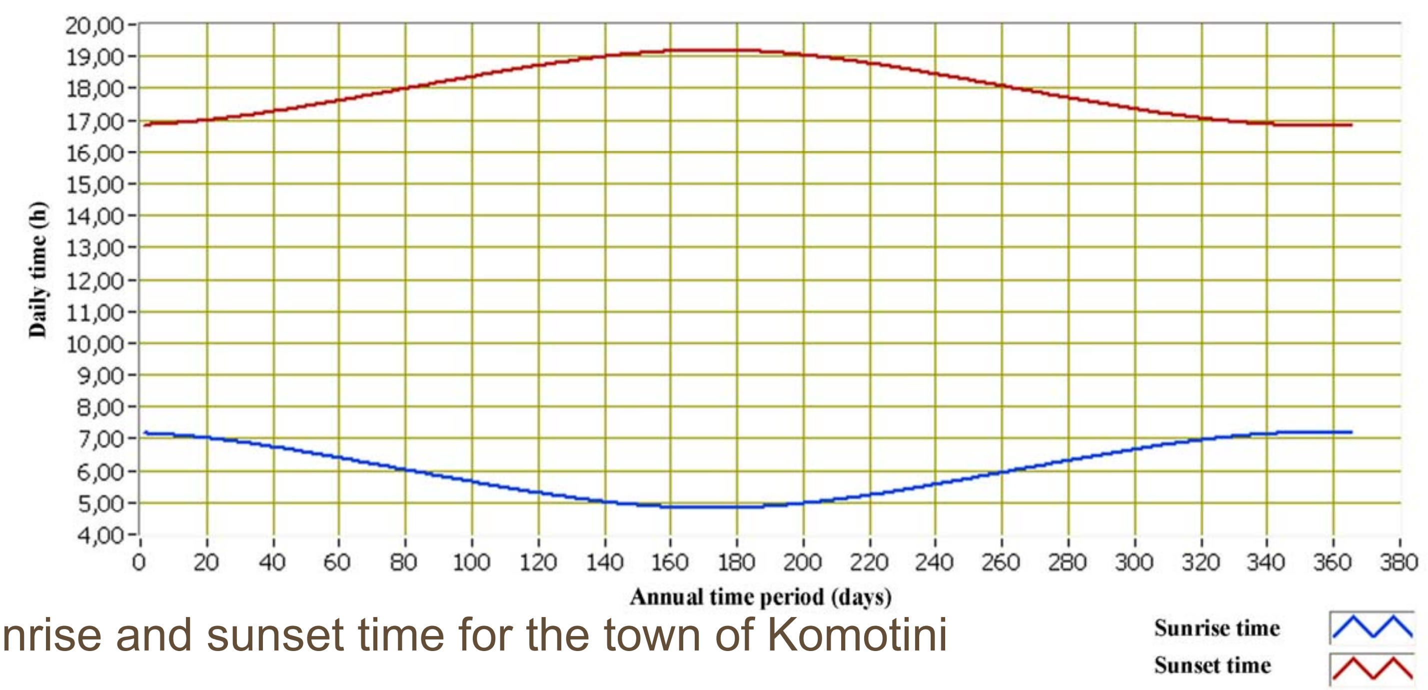
Source: Minnesota Department of Transportation, Office of Traffic Engineering,“Roadway Lighting Design Manual”, June 2001.

Time periods of street lighting in Komotini

- The daytime periods are thoroughly calculated for the whole year and for the town of Komotini ($\varphi=41.07^o$ - $\lambda=25.24^o$), using the fundamental solar geometry theory.
- The calculation is executed for monthly time periods, adopting the 21st day of each month as the characteristic day of it, as far as the daytime duration is concerned.
- In this calculation the time between the sunset and the beginning of the street lighting operation is set to 15min. The same time is set between the power off of the street lighting and the sunrise.

Time periods of street lighting in Komotini

Generally the daytime period annual variation is easily calculated from the daily sunrise and sunset time, for each day of the year, following the fundamental solar geometry theory.



Annual variation of sunrise and sunset time for the town of Komotini

Time period of street lighting operation in Komotini

Month	Mean monthly daytime (h/day)	Street lighting daily operation time (h/day)	Street lighting monthly operation time (h/month)
Jan	14.48	13.98	433.4
Feb	13.32	12.82	359.0
Mar	12.05	11.55	358.1
Apr	10.60	10.10	303.0
May	9.50	9.00	279.0
Jun	9.05	8.55	256.5
Jul	9.47	8.97	278.1
Aug	10.60	10.10	313.1
Sept	12.04	11.54	346.2
Okt	13.40	12.90	399.9
Nov	14.53	14.03	420.9
Dec	14.95	14.45	448.0
Total			**4,195.0**

Street lighting annual electricity consumption

Road	Utility measurements' results (kWh)	Theoretical calculation results (kWh)	Divergence (%)
Heroes Avenue	77,380	62,296	19.5
Kondilis & Plastiras streets	37,822	38,070	-0.7

The observed divergence between the real electricity consumption measurement from the utility and the theoretically calculated one, specifically on Heroes Avenue, is most possibly caused by the operational timer settings for the lamps' power on and off time.

Proposed energy saving actions regarding the street lighting in the town of Komotini

Proposed actions summary

The proposed actions towards the electricity saving on the street lighting in the town of Komotini are:

- the substitution of the existing MFB lamps with either High Pressure Sodium (HPS) lamps, with nominal power of 150W, or LED lamps with nominal power of 110W
- the installation of a remote, automatic lighting monitoring and control system.

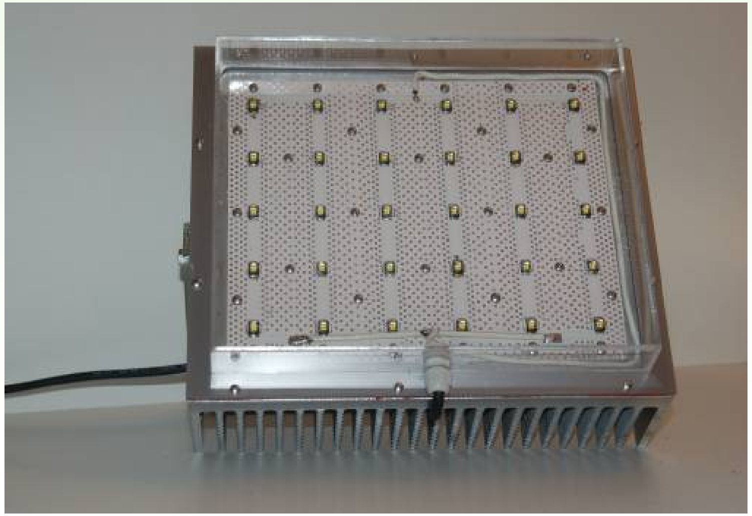
Existing and proposed lamps specifications

Specifications	MFB mercury lamp 250W	High pressure sodium lamp 150W	LED lamp 110W
Lamp's nominal power (W)	250	150	110
Ballast power (W)	25	15	10
Total lamp's and ballast's power (W)	275	165	120
Initial lamp's luminant flux (lumen)	12,500	15,000	12,500
Luminant flux after the 40% of the lamp's life period (lumen)	10,000	12,000	12,000
Lamp's total efficiency (lumen/W)	45	91	116
Lamp's life period (h)	<12,000	<12,000	>70,000

Existing and proposed lamps' types

MFB mercury lamp

HPS lamp



LED lamp

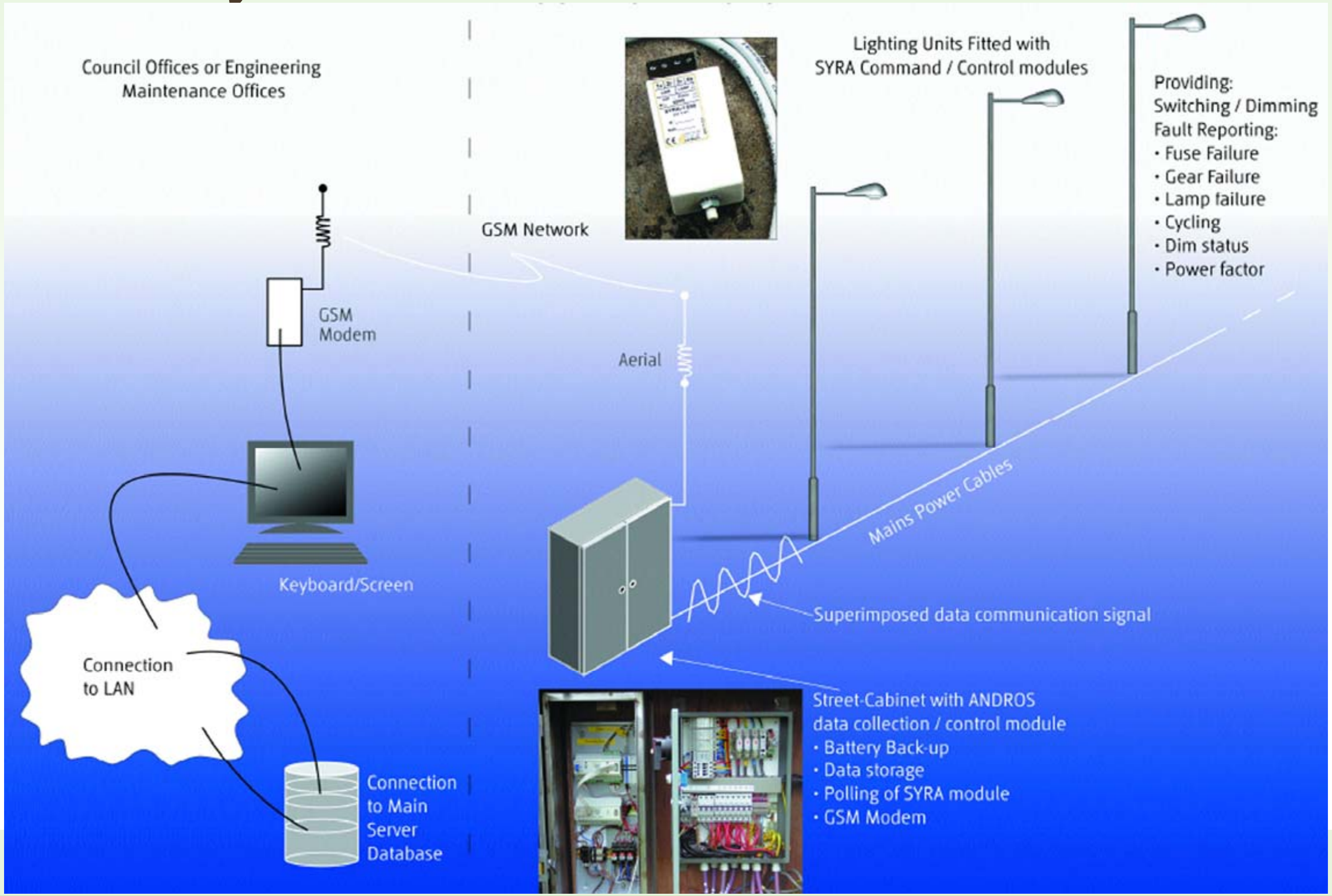
Remote, automatic lighting monitoring and control system

- The system’s architecture must be “flexible”, in the sense that the system must be applicable and adaptable in any possible future modification of the installed lighting equipment.
- Taking into account that the ultimate under control unit of every lighting system is the lamp, the remote system must be applicable in every possible lamp’s type (Low or High Pressure Sodium Lamps, Mercury Lamps, HQI Lamps, Metal Halide Lamps , Incandescent Lamps, LED Lamps et), every lamps’ brand and every possible lamps’ nominal power (from 10W to at least 1,000W).
- Moreover, the remote system must be able to adjust the lamp’s power consumption, following the settings of the supporting bi-power or electronic ballast.

Remote, automatic lighting monitoring and control system

- The system's structure must follow an inverse tree topology, namely from the sub-level units (lamps), the user should be gradually led to more complex and collecting monitoring and control units (pillars), until the whole structure is integrated to a handy, effective and user friendly interface, which can be nothing else but a central server, equipped with the appropriate software.

Remote, automatic lighting monitoring and control system



Remote, automatic lighting monitoring and control system

Local recording and controlling units

The scope of these units is to record data, as well as to receive/send orders regarding the operation of each lamp separately. They must be able to execute four tasks:

- setting the lamp operation on and off
- adjusting the lamps’ power consumption in nominal/half operational mode, in case of lamps supported by bi-power ballasts, or in gradual reduction, in case of lamps supported by electronic ballast
- combined operation of the abovementioned tasks
- lamps’ on and off operation supported by embodied relay (clever lamp).

Remote, automatic lighting monitoring and control system

A-stage centralization unit

The scope of this unit is the collection, the analysis and the transmission of the data received from the system’s ultimate units (lamps) in a central unit for each lighting pillar. This unit should exhibit the ability of two-way communication with:

- the local events’ recording and orders’ send & receive units, installed for every lamp, through the power line communication technology, using the required filters (inductive and capacitive) and devices
- the B-stage centralization unit, through the GSM technology.

Remote, automatic lighting monitoring and control system

B-stage centralization unit

- This is a data collection and analysis unit, with the possibility of remote monitoring and controlling of the ultimate system’s units (lamps), through the A-stage centralization unit.
- It consists of a central server, equipped with a specialized software. This software must provide all the required facilities for the user, including depicting methods in a graphical environment, data reception, analysis, control and storing, sending orders etc.

Remote, automatic lighting monitoring and control system

<u>Example of a local recording unit</u>

Such a unit can consist of a **bi-power ballast**, co-operated with a **changeover switch**, that enables the automatic adjustment of the lamp's operational power from the nominal one to a reduced value (almost the half of the nominal).

&

Remote, automatic lighting monitoring and control system

Example of a local recording unit

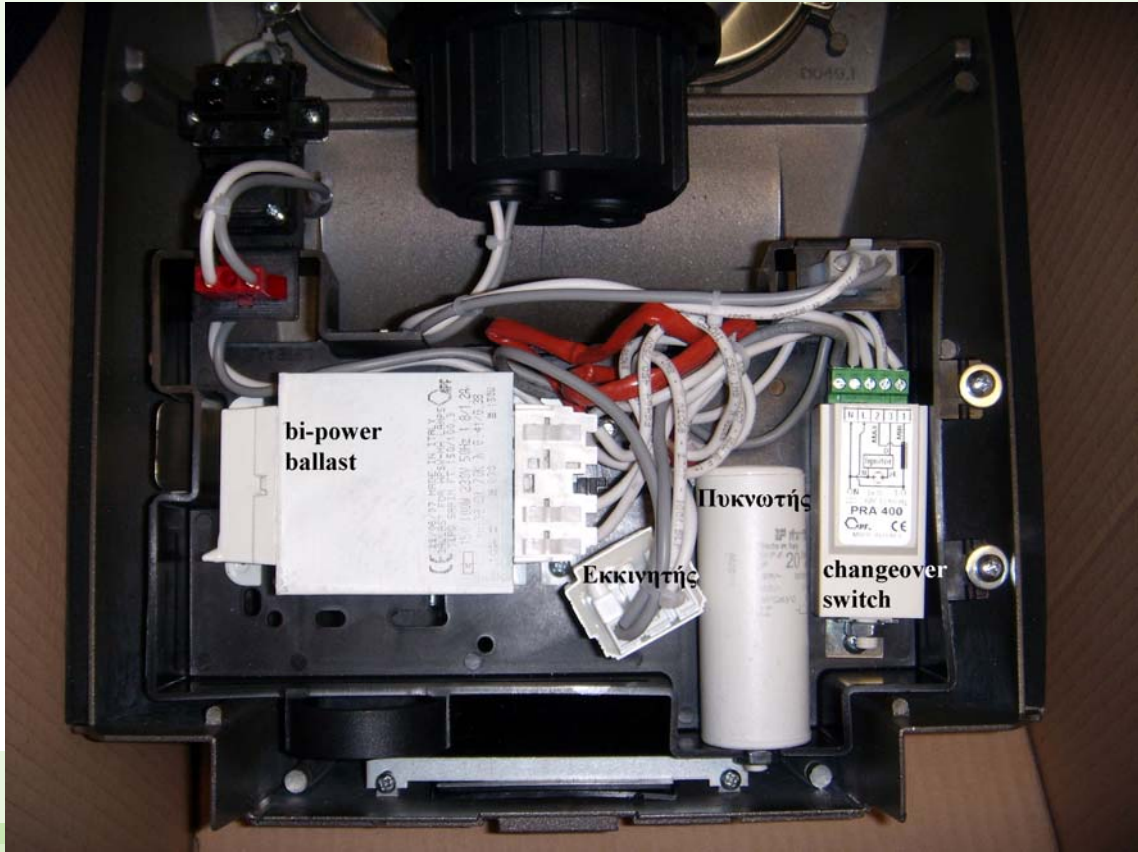
The control of the time period during which the lamps operate with reduced power consumption can be achieved with two ways:

- With the use of a **Bi-Power Ballast + Changeover Switch**, controlled by a timer. The time period of lamps' reduced power operation is set manually (depending of the year's season). For the integration of the system a new conductor is required for the connection of the timer with the lamp.
- With the use of a **Bi-Power Ballast + Changeover Switch**, equipped with a micro-processor, that will set the operational power of the lamp. In this case there is no need for extra conductor installation, a fact that makes this option ideal for existing lighting systems.

Remote, automatic lighting monitoring and control system

Example of a local recording unit

- The micro-processor can be set automatically in order to "follow the sun route" and, consequently, the daytime duration variation versus the year.



Remote, automatic lighting monitoring and control system

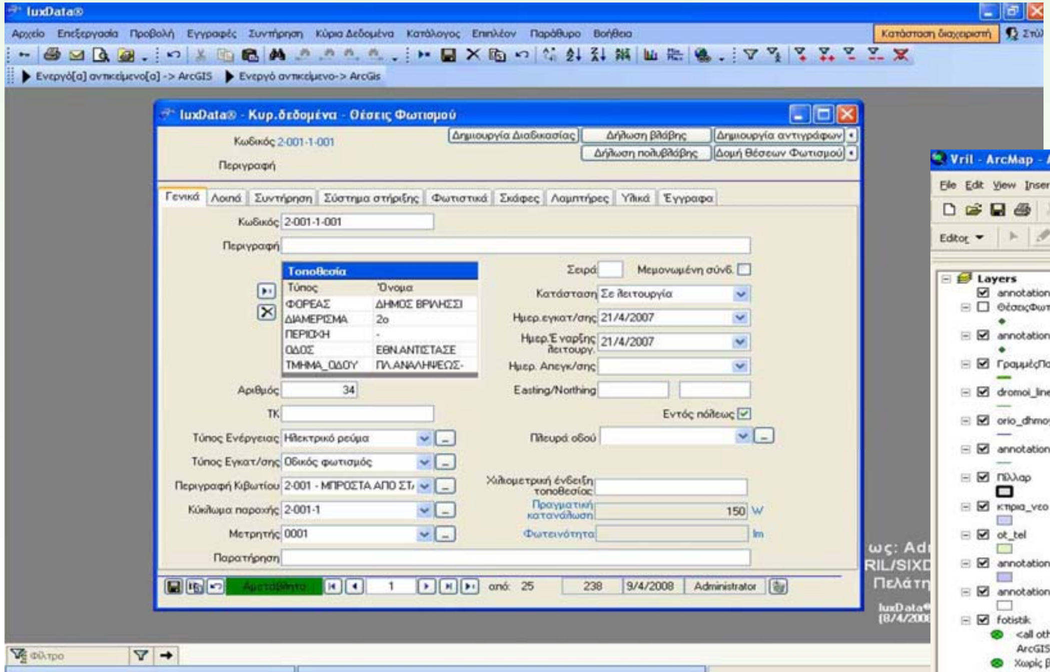
Example of a B-stage centralization unit

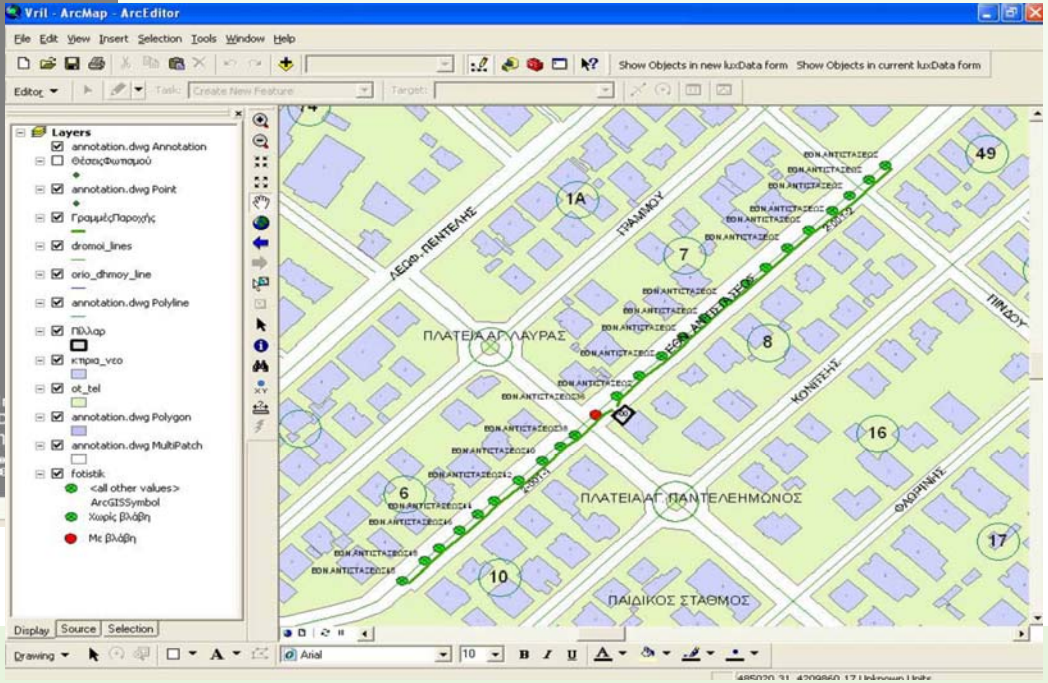
- This unit is installed in the lighting pillar of the lamps that will control.
- It includes:
  - a data logger
  - an electrochemical battery as a back-up energy source
  - a GSM modem for data transporting.

Remote, automatic lighting monitoring and control system

Example of a B-stage centralization unit

A specialized software installed in a central server.

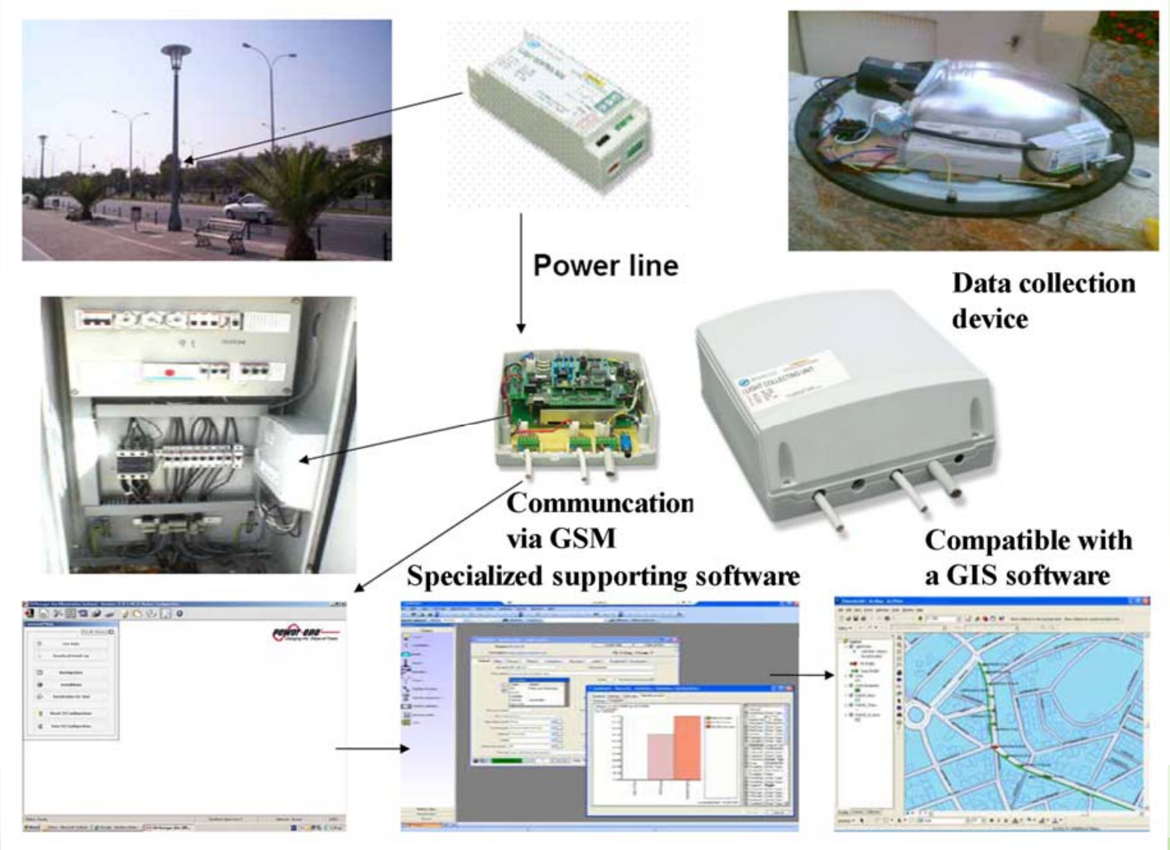




The central server communicates via a GSM modem with the A-stage centralization units.

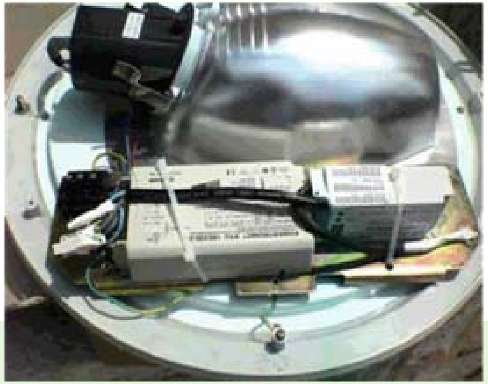
Remote, automatic lighting monitoring and control system

Example of a remote lighting monitoring and control system



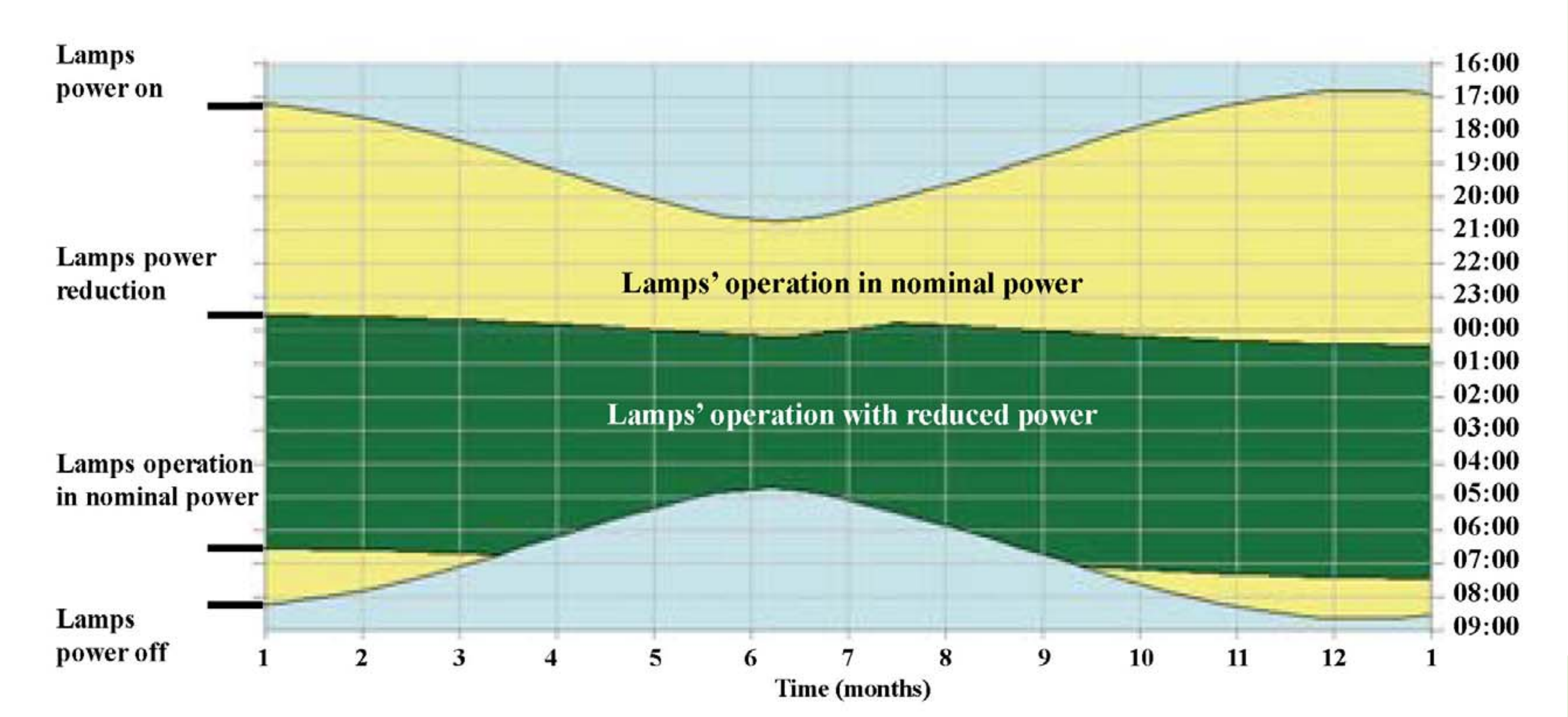
Remote, automatic lighting monitoring and control system

Example of a remote lighting monitoring and control system



Remote, automatic lighting monitoring and control system

Annual power consumption and time period variation of the street lighting operation



Energy saving calculation in the street lighting of Komotini

Electricity consumption saving on street lighting of Komotini

The reduction of the electricity consumption on street lighting of the town of Komotini will be the result of the following actions:

- the reduction of each lamp's nominal power from 275W (MFB lamps) to 165W (HPS lamps) or 120W (LED lamps), including the ballast's power of each lamp type
- the power on and off of the lamps following the setting of the local recording and control unit according to the astronomical clock
- the gradual reduction of the lamps' power consumption.

Operational scenarios of the street lighting in Komotini after the proposed actions

- Taking into account that the operational power of each lamp can be adjusted separately, the number of the possible operational combinations that can be performed for the gradual reduction of the lamps' operational power, is practically infinite.
- In the frames of the present case study, the following lighting operation schedule will be performed:
  - from the sunset to 22:00, all the lamps operate on their nominal power
  - from 22:00 to 00:00, the lamps operate on the 67% of their nominal power
  - from 00:00 until the sunrise, the lamps operated on the 50% of their nominal power.

Annual time period for each one of the previously presented cases

Month	T_a (h/month)	T_b (h/month)	T_c (hmonth)	T_{tot} (h/month)
	Power on – 22:00	22:00 – 00:00	00:00 – Power off	Total
Jan	139.50	62.00	231.88	433.4
Feb	108.08	56.00	194.88	359.0
Mar	103.23	62.00	192.88	358.1
Apr	82.50	60.00	160.50	303.0
May	69.75	62.00	147.25	279.0
Jun	57.90	60.00	138.60	256.5
Jul	64.17	62.00	151.90	278.1
Aug	83.08	62.00	168.02	313.1
Sep	107.10	60.00	179.10	346.2
Oct	136.40	62.00	201.50	399.9
Nov	147.90	60.00	213.00	420.9
Dec	153.45	62.00	232.50	448.0
Total	**1,253.06**	**730.00**	**2,211.95**	**4,195.0**

Annual electricity consumption for street lighting in the examined roads of Komotini

Annual electricity consumption (kWh)						
Consumption time period	With HPS lamps			With LED lamps		
	Heroes Avenue	Kondilis & Plastiras streets	Total	Heroes Avenue	Kondilis & Plastiras streets	Total
Electricity consumption during t_a	11,165	6,823	**17,988**	8,120	4,962	**13,082**
Electricity consumption during t_b	4,358	2,663	**7,021**	3,169	1,937	**5,106**
Electricity consumption during t_c	9,854	6,022	**15,876**	7,167	4,380	**11,546**
Total	**25,377**	**15,508**	**40,885**	**18,456**	**11,279**	**29,735**

Annual electricity saving

	Heroes Avenue	Kondilis & Plastiras str.	Total
Existing annual electricity consumption (kWh)	77,380	37,822	115,202
Annual electricity consumption with HPS lamps (kWh)	25,377	15,508	40,885
Annual electricity consumption with LED lamps (kWh)	18,456	11,279	29,735
Annual electricity saving with HPS lamps (kWh)	52,003	22,314	74,317
Annual electricity saving with LED lamps (kWh)	58,924	26,543	85,467
Annual electricity saving with HPS lamps (%)	67.20	59.00	64.51
Annual electricity saving with LED lamps (%)	76.15	70.18	74.19

Economic results

Project's set-up cost

No	Description	Unit	Quanity	Unit cost (€)	Total (€)
1a	Purchase, installation and connection of the HPS lamps	piece	87	60	5,220
1b	Purchase, installation and connection of the LED lamps	piece	87	300	26,100
2	Purchase and installation of the remote monitoring and control system	piece	1	25,000	25,000
	Total set-up cost with HPS lamps (€):				**30,220**
	Total set-up cost with LED lamps (€):				**51,100**

Payback period of the total set-up cost

	Set-up cost (€)	Annual electricity consumption saving (kWh)	Annual electricity purchase cost reduction (€)	Payback period (years)
Project's implementation with HPS lamps	30,220	74,317	6,775	4.46
Project's implementation with LED lamps	51,100	85,467	7,792	6.56

Electricity purchase price: 0.09117€/kWh.

Payback time period
Alternative implementation scenarios

Street lighting system	Annual electricity consumption (kWh)	Annual electricity saving		Annual electricity purchase cost reduction (€)	Project's set-up cost (€)	Payback time period (years)
		(kWh)	(%)			
Existing	115.202	-	-	-	-	-
Substitution of the MFB lamps with HPS lamps	71.730	43,472	37.74	3,963	5,220	1.32
Substitution of the MFB lamps with LED lamps	50.270	64,932	56.36	5,920	26,100	4.41

Remote monitoring and control system is no included In any one of the above lighting systems

Comparative table for the economic efficiency of the proposed actions

Action	Annual electricity saving (kWh)	Set-up cost (€)	Specific set-up cost over the annual electricity saving (€/kWh)
Substitution of the existing MFB lamps with HPS lamps	43,472	5,220	0.1201
Substitution of the existing MFB lamps with LED lamps	64,932	26,100	0.4020
Installation of the remote monitoring and control system with HPS lamps	30,845	25,000	0.8105
Installation of the remote monitoring and control system with LED lamps	20,535	25,000	1.2174

End of presentation

Thank you for your attention