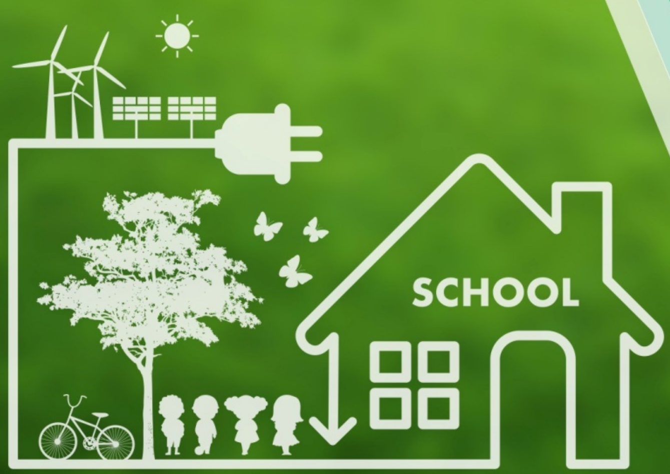

Transferring Energy Efficiency in Mediterranean Schools (TEESCHOOLS)

6th International Conference on Renewable Energy Sources & Energy Efficiency – New challenges

University of Cyprus, Nicosia

01 - 02/11/2018

Cyprus Energy Agency

ΕΝΕΡΓΕΙΑΚΟ ΓΡΑΦΕΙΟ ΚΥΠΡΙΩΝ ΠΟΛΙΤΩΝ

Maria Achilleos

Architectural Engineer, M.Sc.

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The Cyprus Energy Agency

- Non Governmental, Non profit organization
- Officially established on the 09/02/2009

Vision

"to contribute actively to the conservation of energy resources, protecting the environment and contributing to the quality of life!"

Specific objectives

"Promotion of renewable energy sources, sustainable transport, improvement of energy efficiency and contribution to the mitigation and adaptation to climate change"

How we do this

Training Seminars - Exams and certification - Raising Awareness - GPP Supporter - Technical studies - Covenant of Mayors - **European projects**

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The TEESCHOOLS project

...in simple words

Duration	Budget	Funding	Consortium	Energy audits	Objective
3 years From 02/2017	2,840,000 €	Interreg MED	11 partners 7 countries	> 50	

"Development of a set of tools and methodologies to help Municipalities and buildings' managers conduct energy audits in an easy and cost effective way." –

is NZEB scenario feasible?

→ 5 schools were selected in Cyprus based on pre-defined criteria

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The TEESCHOOLS project

Key outputs

- **Integrated set of tools supporting energy efficiency management in schools** with carbon footprint calculator; best practices database for NZEB energy renovation of school buildings; financial solutions and schemes for energy efficiency;

- **Pilot applications at school buildings:** energy audits, renovation plans, calculation of carbon footprint of the renovation activities, development of energy service models and financing schemes.

- **E-learning and face-to-face training** of Regional and Municipal technical staff, energy managers and students.

- **Development of policy recommendations** and integration of project outputs to city plans.

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Energy Audits – Experts' Team

Coordinator	**Savvas Vlachos** Certified Energy Auditor for Buildings and Industries	
External Partners	**Dr Apostolos Michopoulos** Energy Audits Coordinator (External – Certified Energy Auditors' Trainer)	**Orestis Kyriakou** Certified Energy Auditor for Buildings & qualified expert for the issue of EPCs

CEA	**Marios Petrakkas** Electrical Engineer – Certified Energy Auditor for Buildings and Industries	**Giannis Kanaris** Mechanical Engineer - Certified Passivhaus Designer	**Maria Achilleos** Architectural Engineer – Qualified expert for the issue of EPCs	**Myrto Skouroupathi** Environmental Engineer

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Methodology

Preliminary Contact → Start-Up Meeting → Data collection → Field Work → Current state analysis → Energy Report → Final Meeting - Solutions

CYS EN 16247-1:2012 Standard

STEP – BY - STEP:

Preliminary contact – Purpose of the energy audit
- Established by the project and the needs of the local schools

Start-Up meeting
- With the school users and managers – role, needs, timeframe, clarifications

Data collection
- Data (energy bills and architectural/technical drawings) have been collected before the on-site visits by the competent bodies.

Auditing and Measurements on-site
- On-sites visits have been established for additional data collection & validation of the acquired data for each school building

Parallel Actions
- *Includes the measurements for 2 weeks (at least) for electricity consumption & for temperature and relative humidity in selected classrooms and the efficiency of the boiler.*

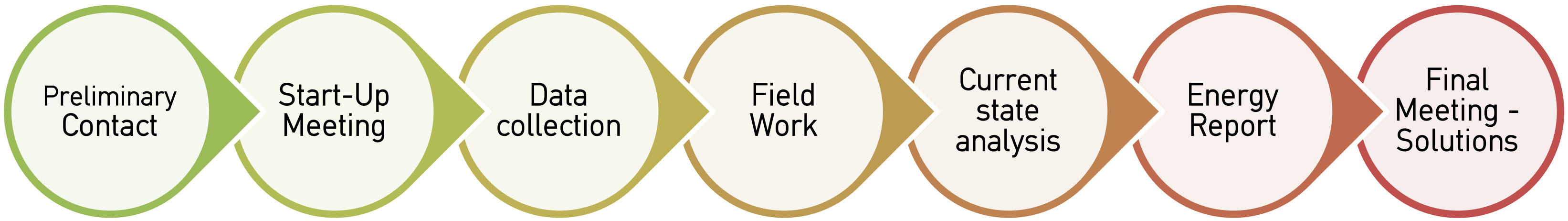
Current state analysis
- Dynamic energy simulations have been established for calibrating the current state analysis (IES-VE)

Identification of the possible energy upgrade measures
- For each school, various scenarios were examined and analyzed from technical perspective

Evaluation of measures
- All the selected scenarios were evaluated based on their energy and economic savings –Technoeconomic feasibility – LCC.

Delivery of the energy report and user training
- Energy reports were established for each participating school – they are currenttly delivered along with further training on energy matters

Methodology



CYS EN 16247-1:2012 Standard

SCOPE OF THE ENERGY AUDIT:

- Building’s Envelope
- Heating system
- Cooling System [where applicable]
- Lighting system
- Auxiliary infrastructure and equipment
- Renewable Energy System [where applicable]

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Methodology

Preliminary Contact → Start-Up Meeting → Data collection → Field Work → Current state analysis → Energy Report → Final Meeting - Solutions

CYS EN 16247-1:2012 Standard

EQUIPMENT USED

FLIR E30 - Infrared Thermal Imaging Camera

EXTECH RHT10 & RHT20 - Humidity and Temperature Datalogger

Kimo Kigaz 100 Combustion Flue Gas Analyzer

Fluke 1735 - Power meter for conducting energy studies and basic power quality logging

Equipment Used

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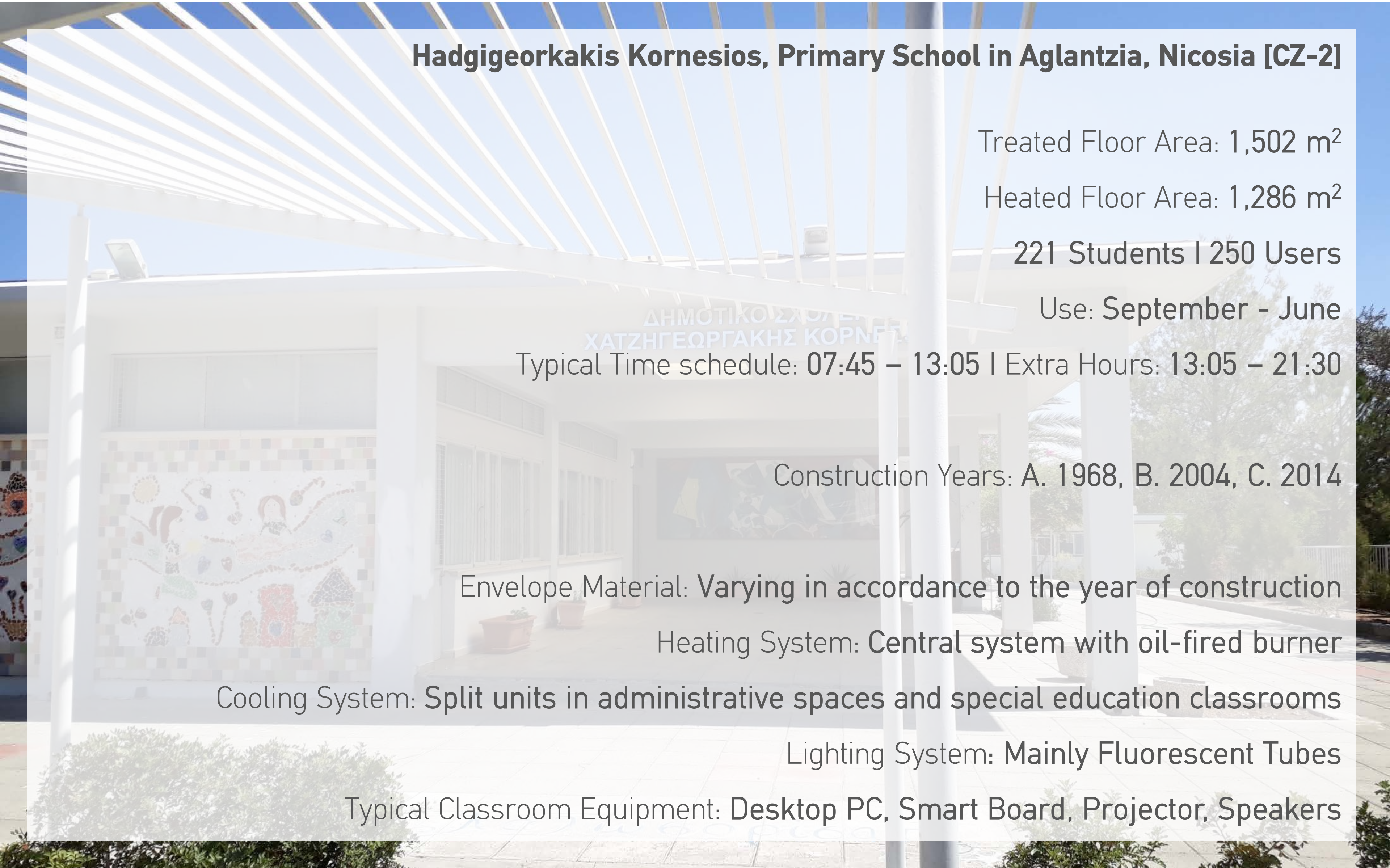
Selected Schools



Hadgigeorkakis Kornesios, Primary School in Aglantzia, Nicosia [CZ-2]

Treated Floor Area: 1,502 m^2

Heated Floor Area: 1,286 m^2

221 Students I 250 Users

Use: September - June

Typical Time schedule: 07:45 – 13:05 I Extra Hours: 13:05 – 21:30

Construction Years: A. 1968, B. 2004, C. 2014

Envelope Material: Varying in accordance to the year of construction

Heating System: Central system with oil-fired burner

Cooling System: Split units in administrative spaces and special education classrooms

Lighting System: Mainly Fluorescent Tubes

Typical Classroom Equipment: Desktop PC, Smart Board, Projector, Speakers

Selected Schools

3rd Primary School Ayios Georgios – Lakatamia, Nicosia [CZ-2]

Treated Floor Area: 2,024 m^2

Heated Floor Area: 1,831 m^2

379 Students I 415 Users

Use: September - June

Typical Time schedule: 07:45 – 13:05 I Extra Hours: 13:05 – 21:30

Construction Years: A. 1987, B. 2008, C. 2014

Envelope Material: Varying in accordance to the year of construction

Heating System: Central system with oil-fired burner

Cooling System: Split units in administrative spaces, labs and special education classrooms

Lighting System: Mainly Fluorescent Tubes

Typical Classroom Equipment: Desktop PC, Smart Board, Projector, Speakers

Selected Schools

Ayios Andreas Primary School (CA and CB), Nicosia [CZ-2]

Selected Schools

Ayios Andreas Primary School (CA and CB), Nicosia [CZ-2]

Treated Floor Area: 1,958 m^2

Heated Floor Area: 1,757 m^2

269 Students I 299 Users

Use: All year

Typical Time schedule: 07:45 – 13:05 I Extra Hours: 13:05 – 20:30

Construction Years: A. 1989, B. 2008 + Partial maintenance works in 2008 and 2013

Envelope Material: Stone and wooden/iron windows, and brick, reinforced concrete, alum. frames

Heating System: Central system with oil-fired burner

Cooling System: Split units in admin. spaces, labs, special education class. and multipurpose room

Lighting System: Mainly Fluorescent Tubes

Typical Classroom Equipment: Desktop PC, Smart Board, Projector, Speakers

Selected Schools

Livadia Primary School – Liadia, Larnaka (CB) [CZ-1]

Treated Floor Area: 960 m^2

Heated Floor Area: 792 m^2

203 [250] Students | 246 [278] Users

Use: September - June

Typical Time schedule: 07:45 – 13:05 | Extra Hours: 13:05 – 21:00

Construction Years: A. 1946, B. 1970 + Partial maintenance works in 2008 and 2017

Envelope Material: Varying in accordance to the year of construction

Heating System: Central system with oil-fired burner

Cooling System: Split units in administrative spaces and special education classroom

Lighting System: Mainly Fluorescent Tubes

Typical Classroom Equipment: Desktop PC, Smart Board, Projector, Speakers, Fans

Selected Schools

Voroklini Primary School – Voroklini, Larnaka [CZ-1]

Treated Floor Area: 1,663 m^2 [up to 2018]

Heated Floor Area: 1,534 m^2 [up to 2018]

400 Students I 438 Users

Use: All Year

Typical Time schedule: 07:45 – 13:05 I Extra Hours: 13:05 – 21:00

Construction Years: A. 1964, B:1974-1979, C:1985, D:1991-2001, E:2004-2009, F:2015, G:2018

Envelope Material: Varying in accordance to the year of construction

Heating System: Central system with oil-fired burner

Cooling System: Split units in administrative spaces, special education classroom and labs

Lighting System: Mainly Fluorescent Tubes

Typical Classroom Equipment: Desktop PC, Smart Board, Projector, Speakers, Fans

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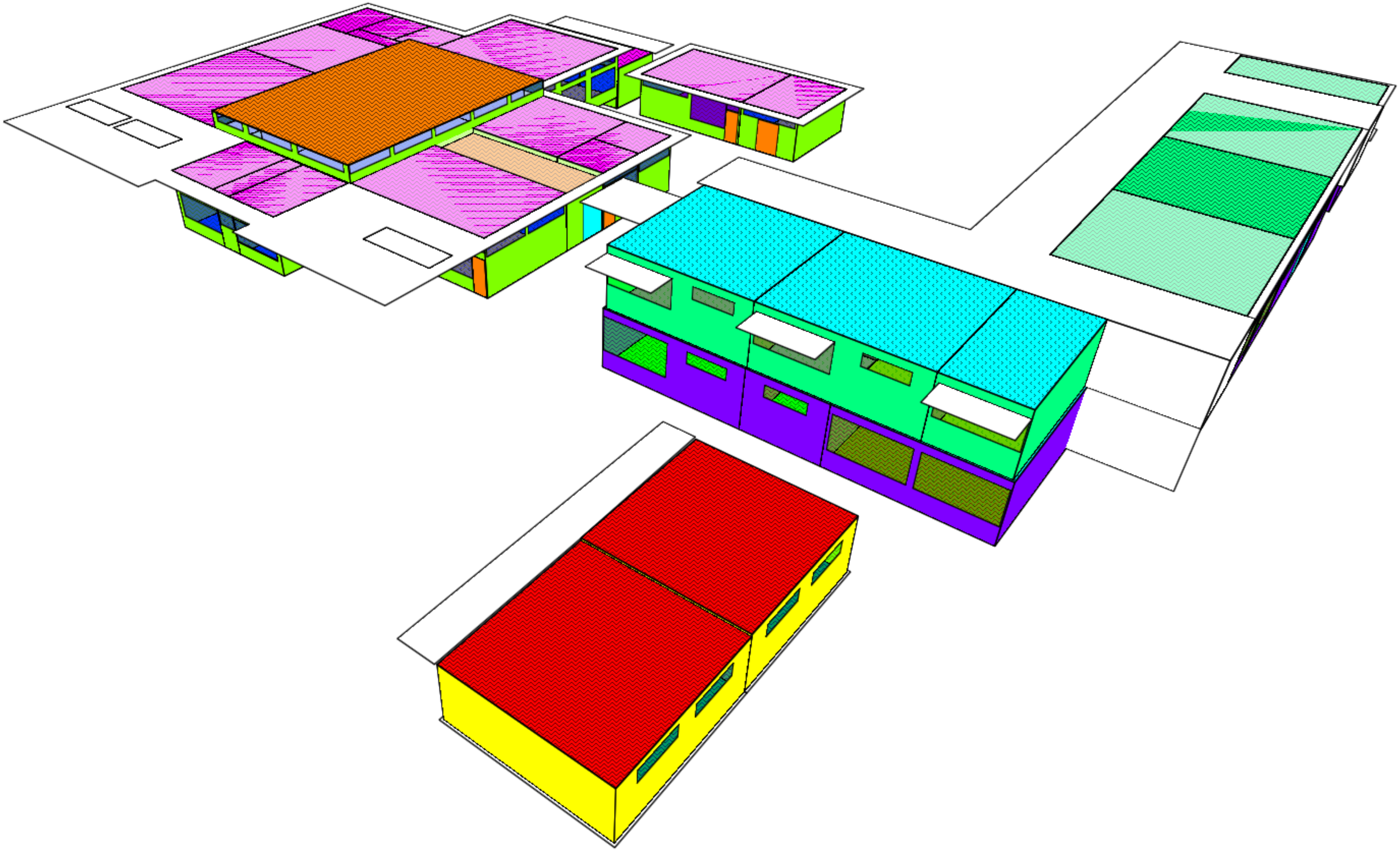
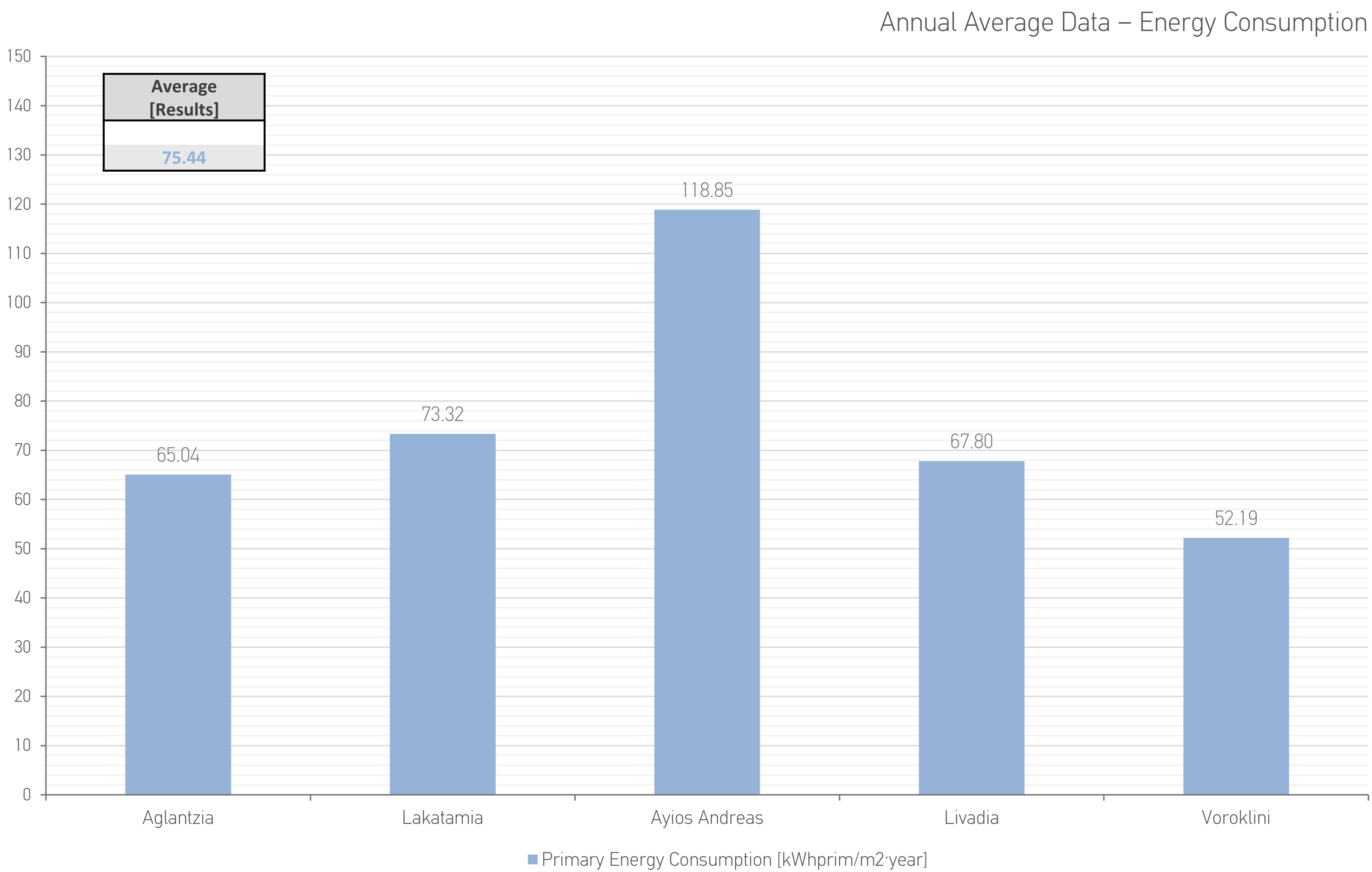
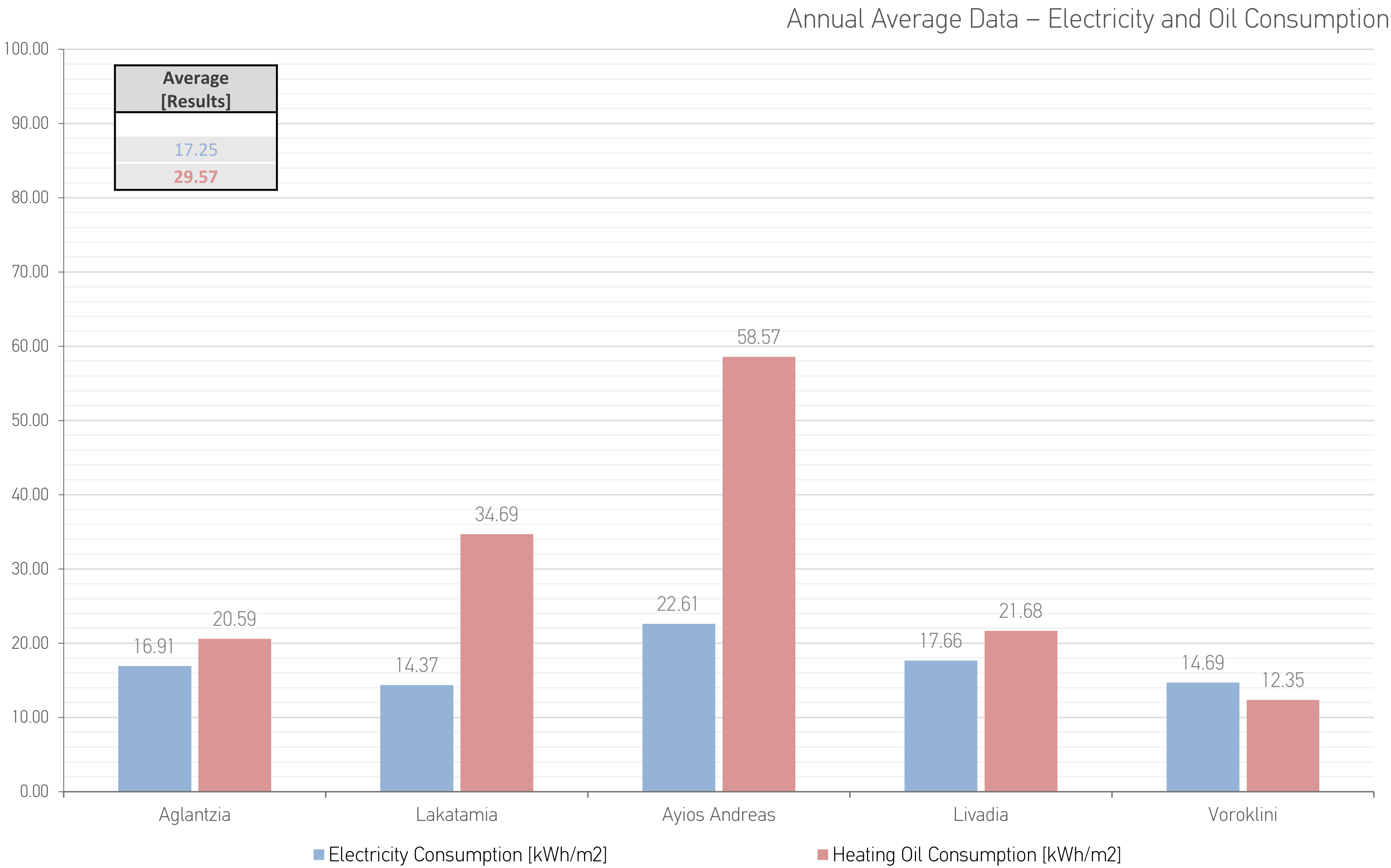
Results



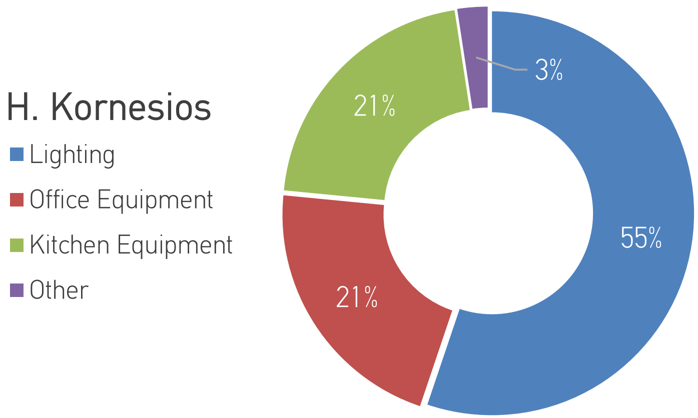
Results [Primary energy per sq.m.]

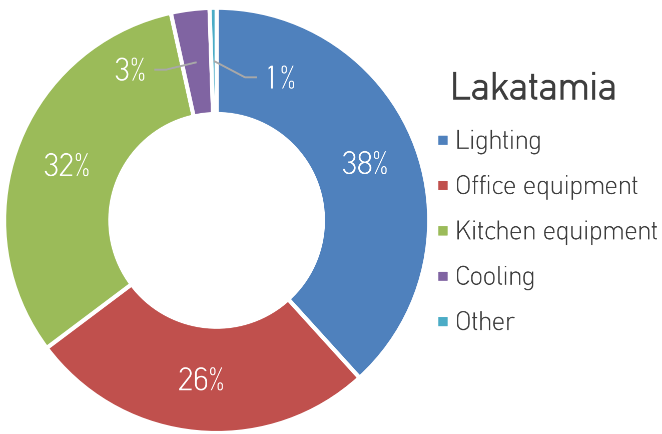


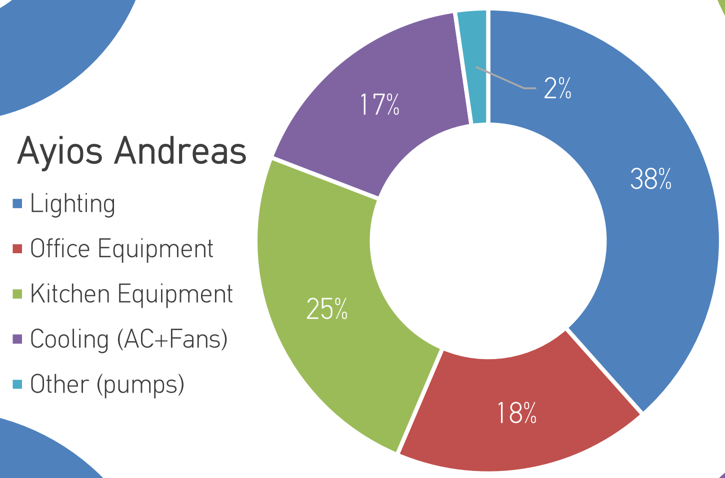
Results [Electricity & Heating per sq.m.]

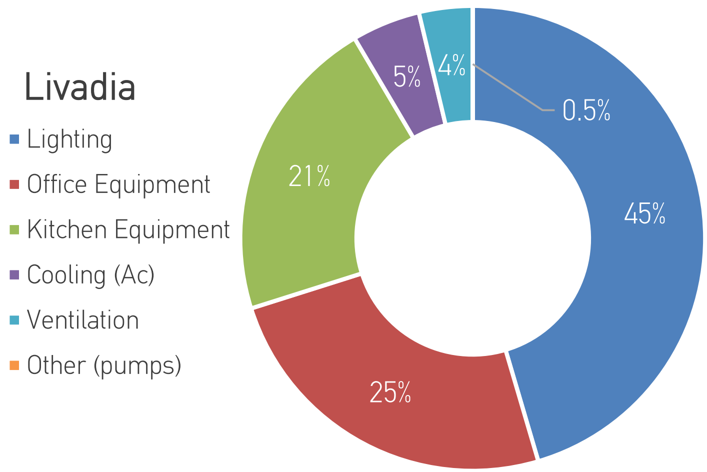


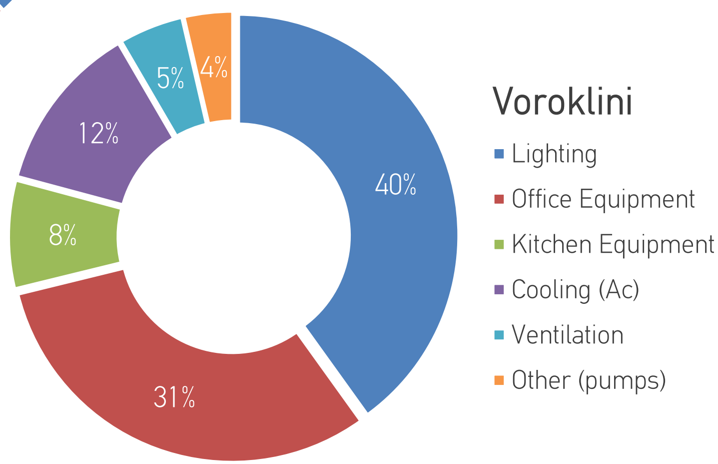
Results [Electricity consumption breakdown]



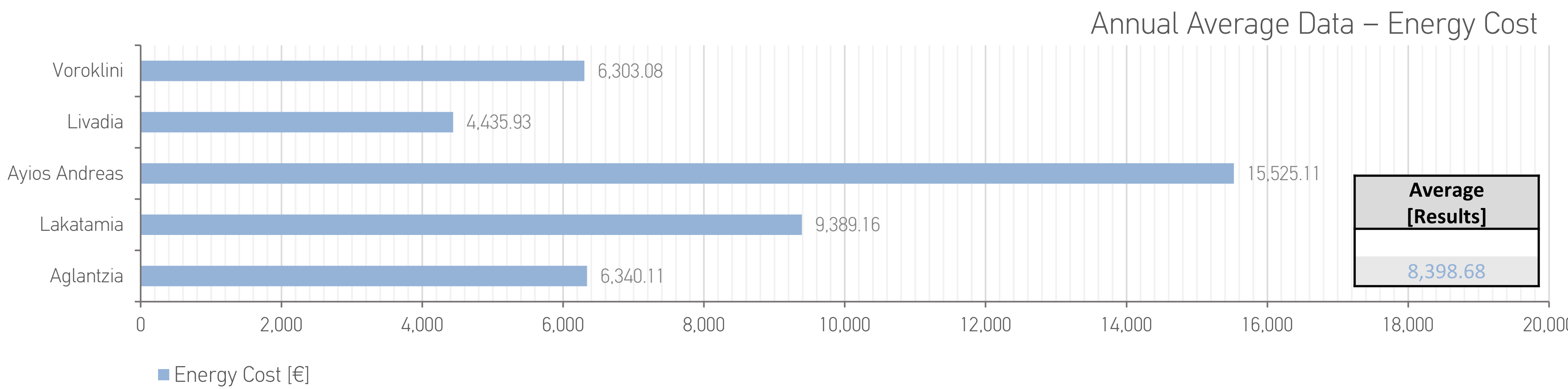


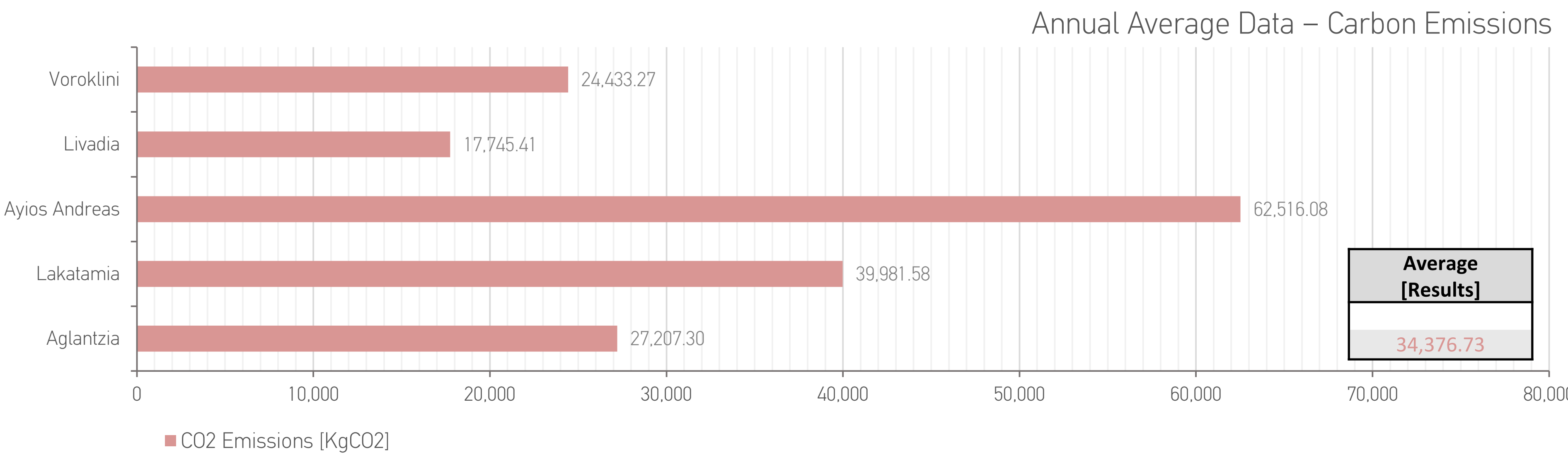






Results [Energy Cost & Carbon Emissions]





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Results [Suggested implementations]

A/A	Description	Average Energy Savings ($kWh_{el/th}$/year)	Average Primary Energy Savings (KWh_{pr}/year)	Average Carbon Emission Savings ($kgCO_2$/year)	Average Initial Cost (€)	Cost per primary energy saved (€/KWh_{pr})
A	Installation of LED lighting	8,203.40	22,149.18	6,513.58	5,088.40	0.22
B	Installation of PV system [capacity varies]	11,566.80	31,230.20	9,184.24	9,533.80	0.30
C	Insulation of the roofs [3 schools]	10,383.33	12,834.33	3,228.33	47,313.33	3.68
D	Insulation or replacement of the heating distribution pipelines	6,238.40	6,862.40	1,659.60	1,389.80	0.20
E	Adjustment and/or maintenance of the boiler [3 schools]	4,306.33	4,737.33	867.50	200.00	0.04
F	NZEB Scenario	**39,872.28**	**76,838.92**	**21,489.33**	**314,563.20**	**4.09**
G	Installation of external shading | Passive strategies	Should be studied individually				
E	Behavioural Change	Seems to have a great impact on the energy consumption of schools				

Installation of A/C units where is needed ?

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State of the Art - Cyprus

	Minimum Energy Efficiency Requirements					nZEB
	21.12.2007 - 31.12.2010	**01.01.2010 - 10.12.2013**	**11.12.2013 - 29.10.2015**	**30.10.2015 - 31.12.2016**	**01.01.2017 - 31.12.2020**	**01.01.2019 (P.B.) 01.01.2021 and afterwards**
	Decree 568/2007	**Decree 446/2009**	**Decree 432/2013**	**Decree 359/2015**	**Decree 119/2016**	**Decree 366/2014**
Ranking - Class	-	≥ B	≥ B	≥ B	≥ B	A
U value - Walls	≤ 0.85 W/m².K	≤ 0.85 W/m².K	≤ 0.72 W/m².K	≤ 0.72 W/m².K	≤ 0.40 W/m².K	≤ 0.4W/m².K
U value – Horizontal structural elements	≤ 0.75 W/m².K	≤ 0.75 W/m².K	≤ 0.63 W/m².K	≤ 0.63 W/m².K	≤ 0.40 W/m².K	≤ 0.4W/m².K
U value of a ground (over non - heated spaces)	≤ 2.0 W/m².K	≤ 2.0 W/m².K	≤ 2.0 W/m².K	≤ 2.0 W/m².K	-	-
U value of the windows	≤ 3.8 W/m².K	≤ 3.8 W/m².K	≤ 3.23 W/m².K	≤ 3.23 W/m².K	≤ 2.90 W/m².K	≤ 2.25 W/m².K
U value – Mean (Walls & Windows)	-	1.3 W/m².K	≤ 1.3 W/m².K	≤ 1.3 W/m².K	≤ 1.3 W/m².K	-
Maximum consumption of primary energy	-	-	-			100 kWh/m².year 125 kWh/m².year
Maximum energy demand for heating	-	-	-			15 kWh/m².year
Maximum window shading coefficient	-	-	0.63	0.63	0.63	0.63
Maximum power of lighting installations at office buildings					10 W / m²	10 W / m²
Share of RES in primary energy consumption	-	Solar Thermal & PVs Providence	Solar Thermal & PVs Providence	Solar Thermal & PVs Providence	25% (Detached) 3% (Apartments) 7% (Non Residential)	25%

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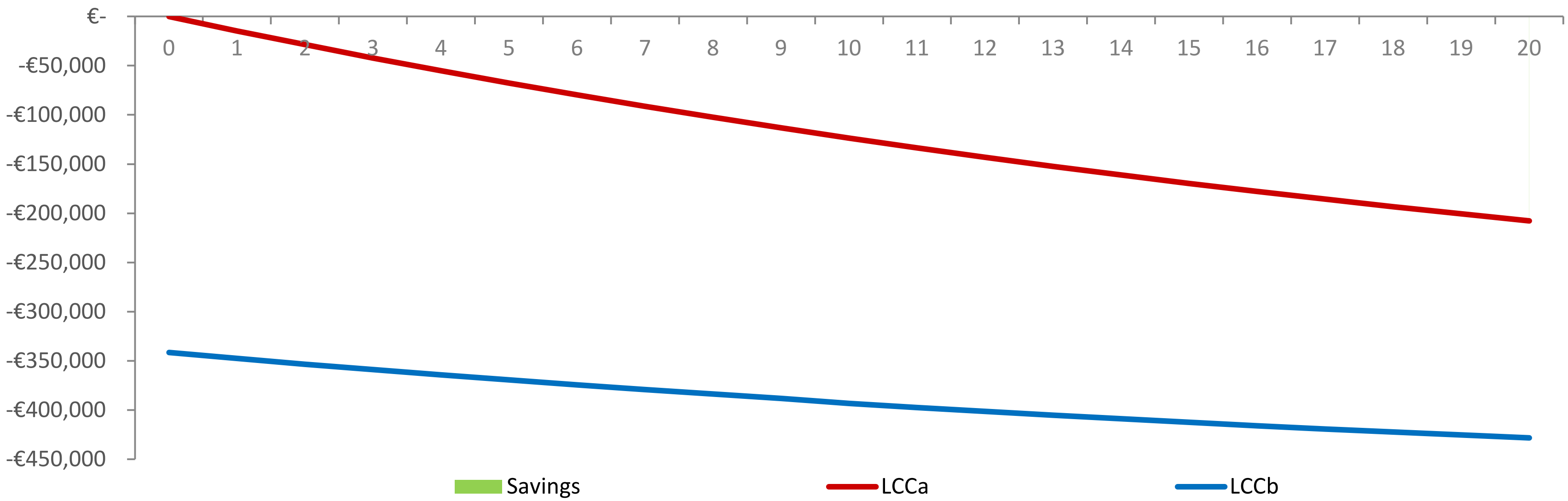
NZEB Feasibility

Agios Andreas Primary School (Cycle A & B) – Nicosia



Index	Value [€]
LCC_A	- 207,609
LCC_B	- 428,318
NCF	- 220,710

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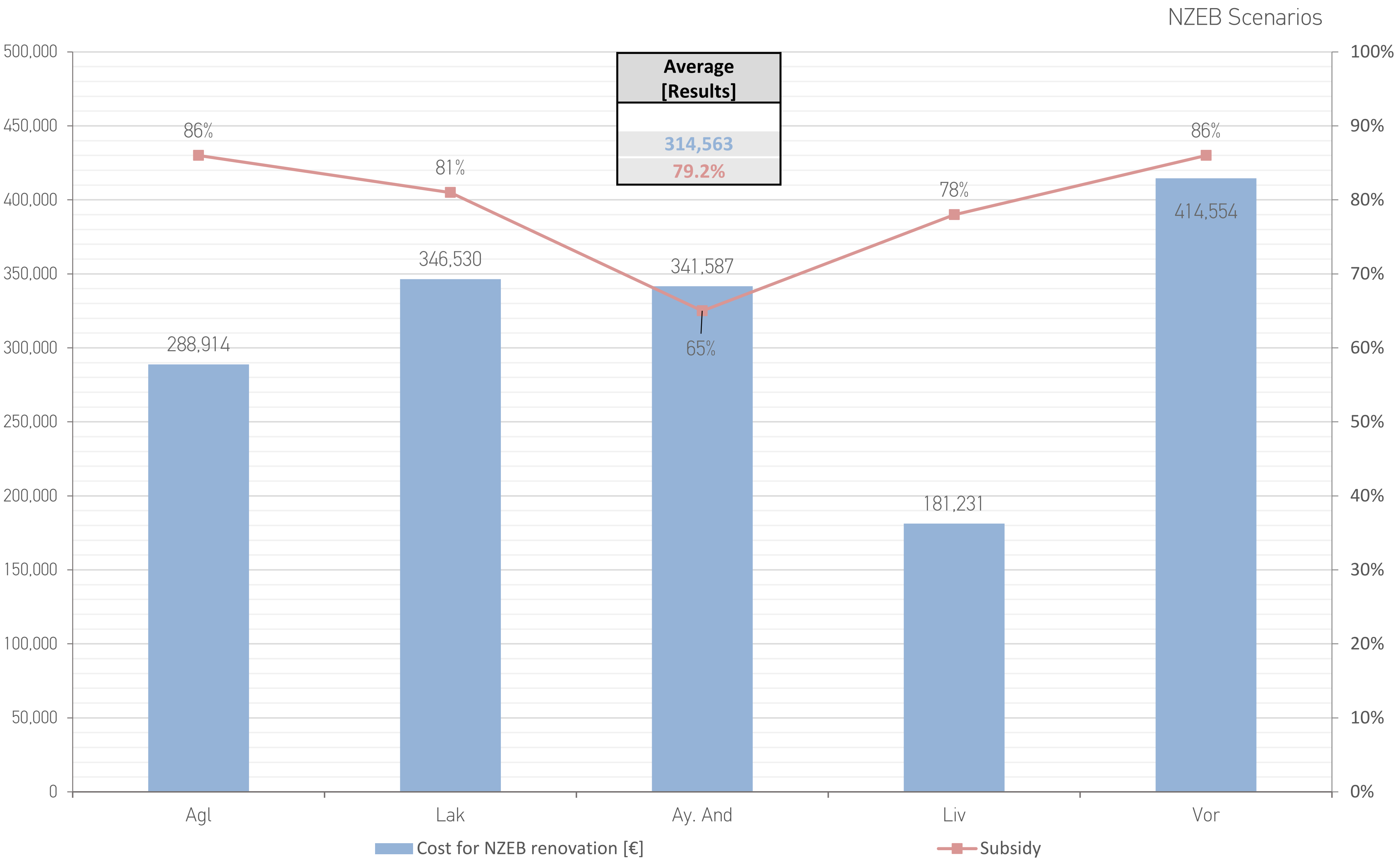
NZEB Feasibility – Subsidy needed



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Thermal Comfort Assessment

- Measures VS Simulated Data

In order to assess the internal conditions of the classrooms, and consequently thermal comfort levels, besides the questionnaires which can be subjective, Data Loggers have been used to record the temperature and the humidity in the rooms. Those loggers where placed for 2 weeks in 2 classrooms, the one that is performing the best and then one that is performing the worst, in accordance to the school's users.

The loggers were taking measurements at a time step of half an hour. Those measurements were compared with the energy model in order to validate its accuracy. As it seems from the next graphs, the model's results are close to the measured ones, therefore this allows the evaluation of other classrooms/spaces where loggers were not placed [other scenarios were tested as well].

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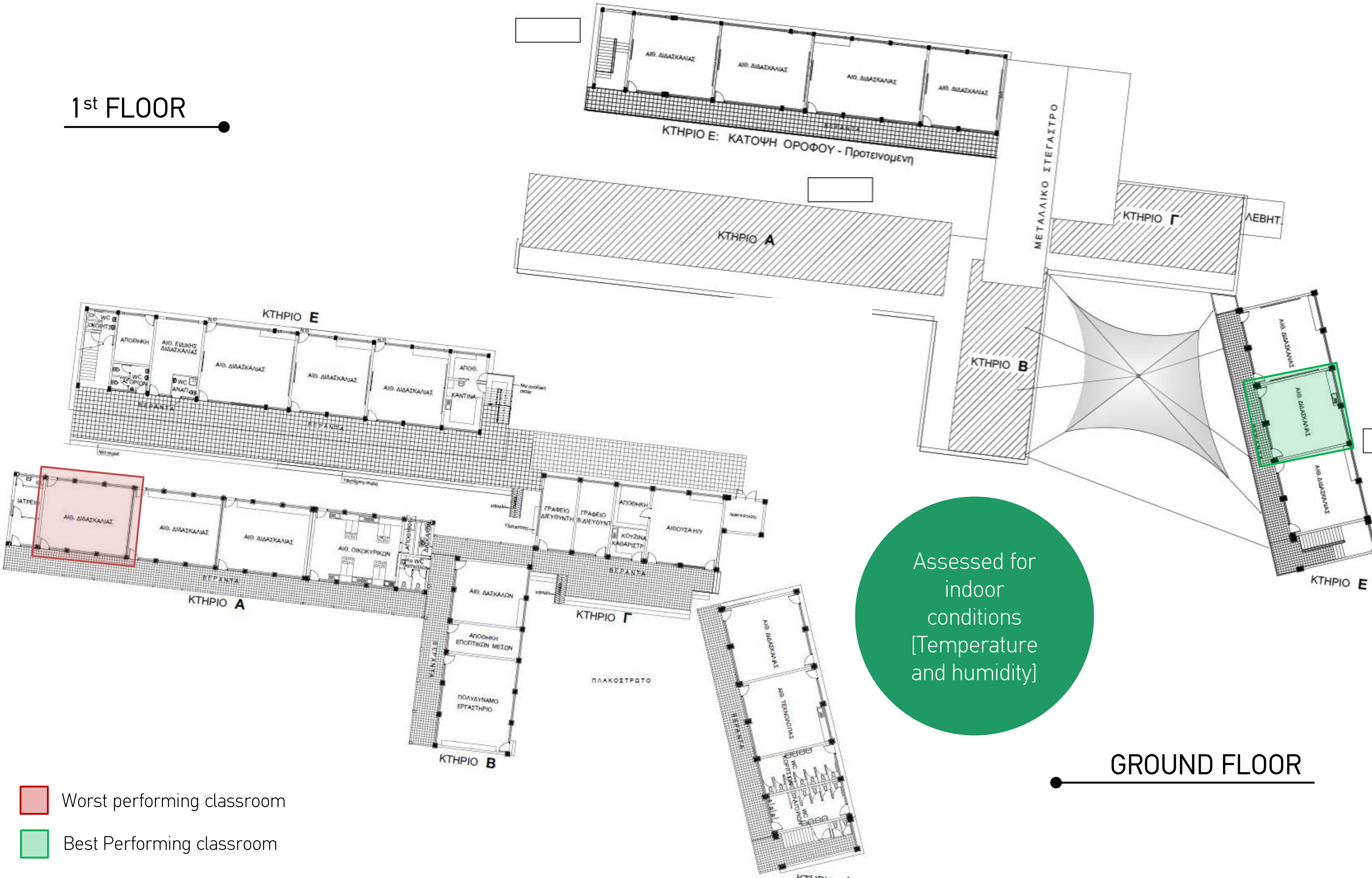
Thermal Comfort Assessment

1st FLOOR



Assessed for indoor conditions [Temperature and humidity]

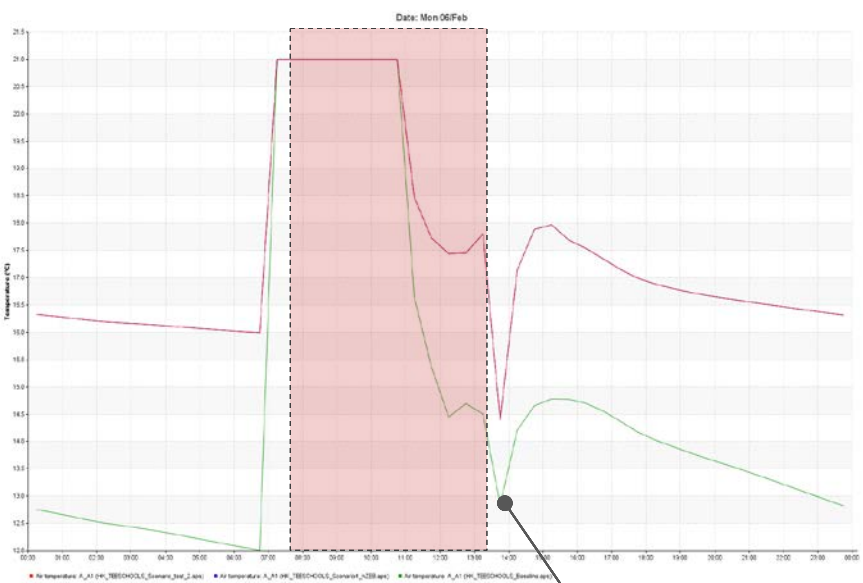
GROUND FLOOR

Worst performing classroom

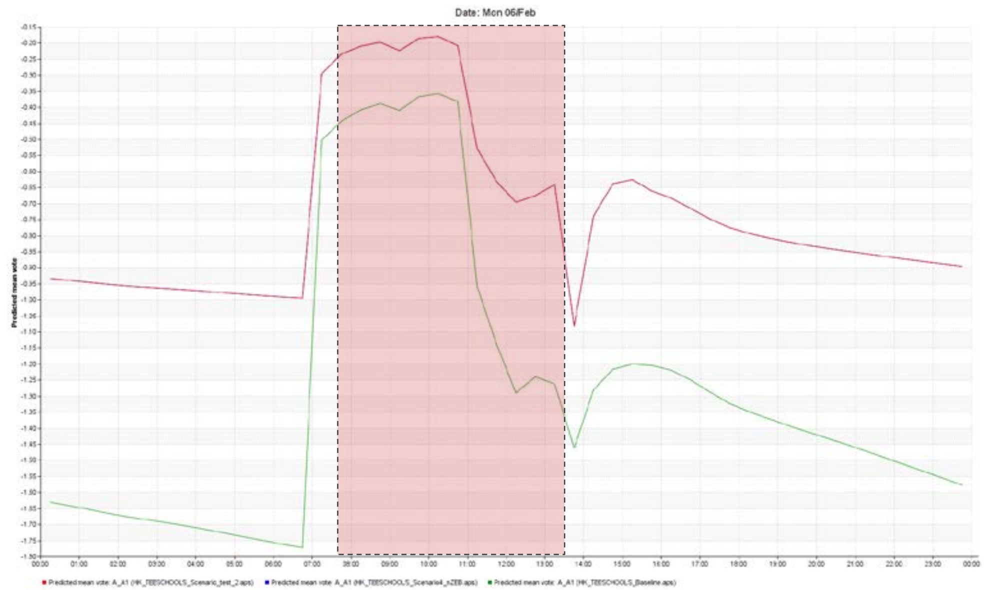
Best Performing classroom

Thermal Comfort Assessment

Results for the worst performing classroom in accordance to the users – Winter [06/02]



Internal temperature [12 - 21.5°C]



PMV [-1.8 - -0.15]

Based on the EN 15251:2012 Standard

- Baseline Scenario
- nZEB Scenario
- Teaching period

Windows open for ventilation – Common practise

Measurements for the baseline scenario

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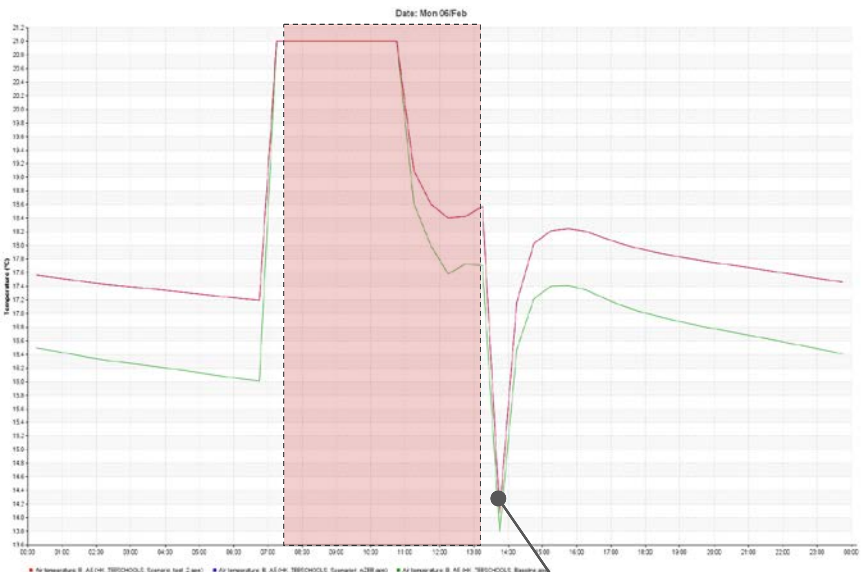
Thermal Comfort Assessment

Results for the best performing classroom in accordance to the users – Winter [06/02]



Εσωτερική Θερμοκρασία [13,6 - 21.2°C]

PMV [-1.2 - -0.10]

- Baseline Scenario
- nZEB Scenario
- Teaching period

Based on the EN 15251:2012 Standard

Windows open for ventilation – Common practise

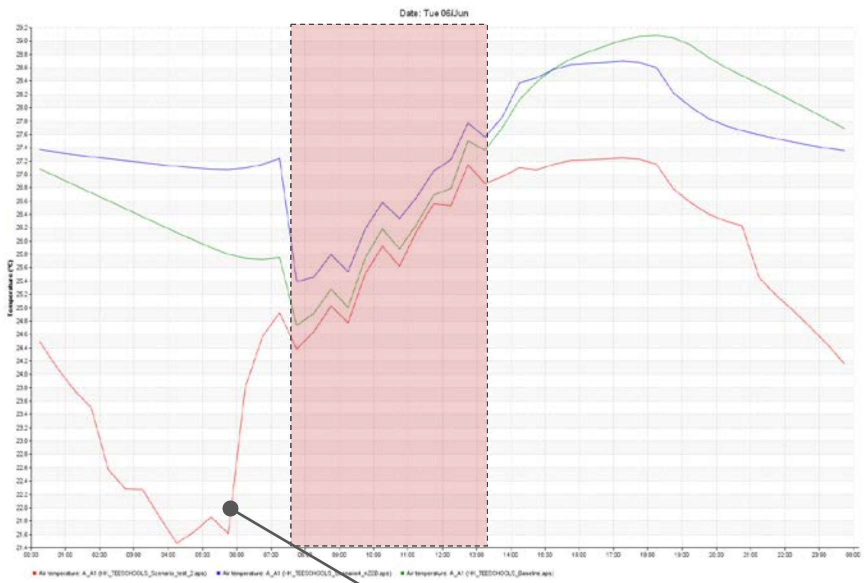
Measurements for the baseline scenario

Project co-financed by the European Regional Development Fund

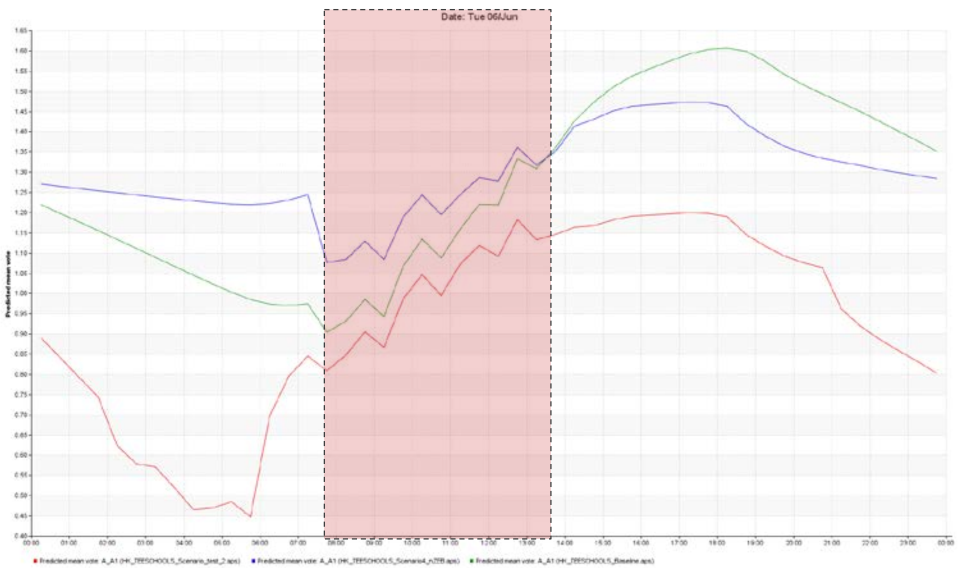
Interreg Mediterranean TEESCHOOLS

Thermal Comfort Assessment

Results for the worst performing classroom in accordance to the users – Summer [06/06]



Εσωτερική Θερμοκρασία [21,4 - 29.2°C]



PMV [+0,40 - +1.65]

- Baseline Scenario
- nZEB Scenario
- nZEB Scenario – Night Cooling
- Teaching period

End of night cooling

Based on the EN 15251:2012 Standard

Calibration for the baseline scenario

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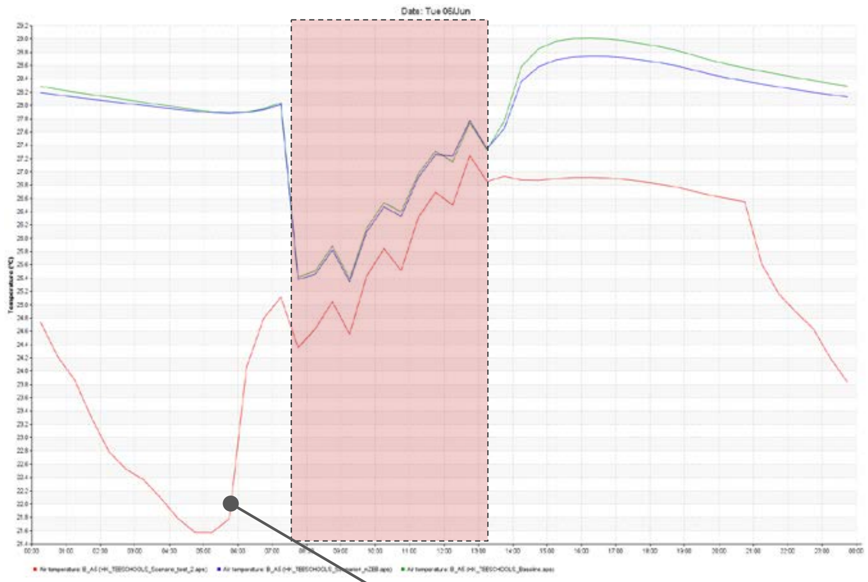
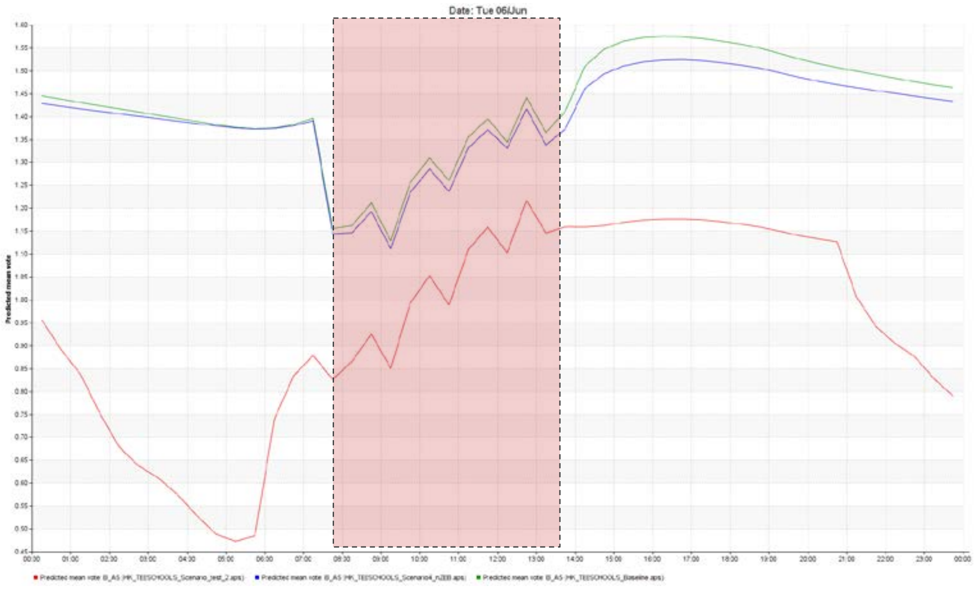
Thermal Comfort Assessment

Results for the best performing classroom in accordance to the users – Summer [06/06]



Εσωτερική Θερμοκρασία [21,4 - 29.2°C]



PMV [+0,45 - +1.60]

- Baseline Scenario
- nZEB Scenario
- nZEB Scenario – Night Cooling
- Teaching period

End of night cooling

Based on the EN 15251:2012 Standard

Calibration for the baseline scenario

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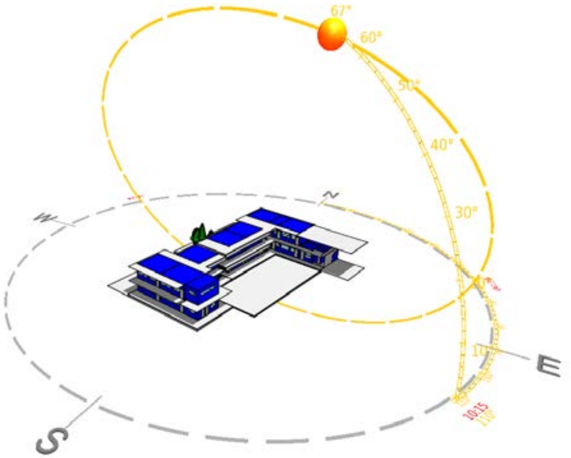
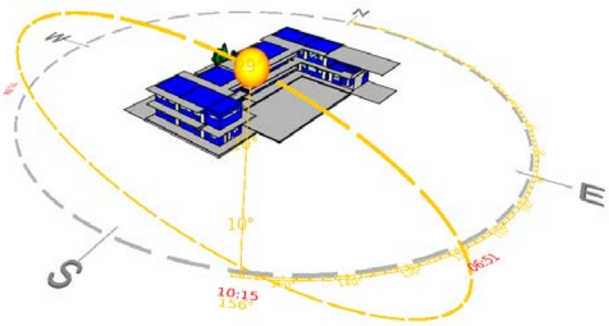
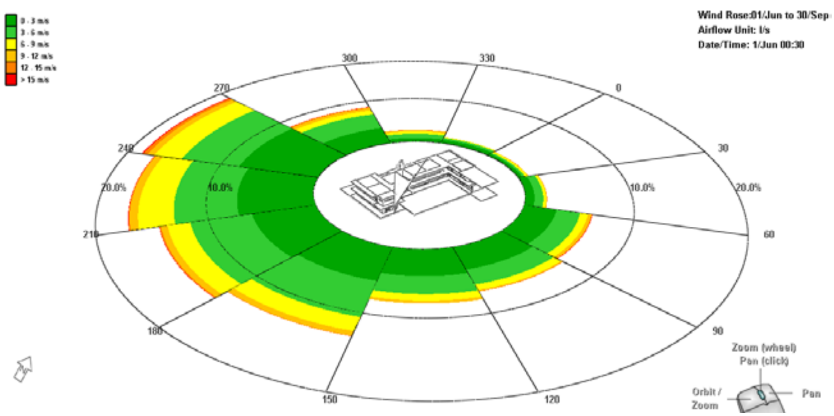
Passive strategies

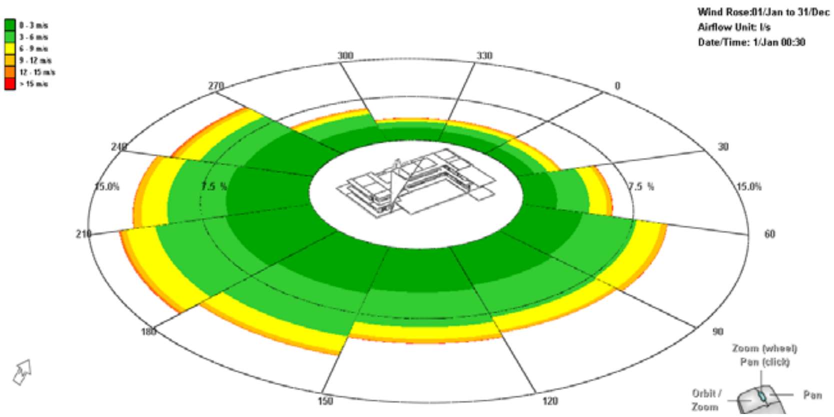




↖ Sun Diagram [21.06 & 21.12]

Wind Rose [Summer - Yearly] ↘





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Next steps

- Thermal Comfort Assessment [finalisation] - *out of the scope of the programme*
- Passive strategies – Suggestions based on Analysis
- Presentation of the results to the schools
- Guidance to ensure funding when possible
- Educational Presentations
- Behavioural change

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Interreg Mediterranean TEESCHOOLS
Project co-financed by the European Regional Development Fund

Conclusions

- Energy consumption in the majority of primary school buildings seems to be **low** when compared to other types of non-residential buildings -or other educational buildings from the participating countries-, therefore the energy saving potential is considered to be limited.
  - Limited hours of operation [Half day, Morning hours, Closed in the summer, Easter holidays, Christmas holidays]
  - Without active cooling usually [Design Templates - Technical Services of the Ministry of Education and Culture]
  - They are not proposed to be implemented by an Energy Performance Contract (EPC). Therefore, it is not proposed to involve an Energy Services Company (ESCO), but to finance the interventions themselves from the School Board's budget.
- The majority **of large scale energy upgrade measures** have negative economic indicators and their economic viability can only be ensured by a subsidy (ie. state aid).
- In addition to the economic indicators, the benefits of thermal comfort, which derives from the implementation of large-scale energy upgrades, should be taken into consideration.
- When adopting the NZEB criteria for the energy upgrading of the school, passive strategies for cooling and heating should be also examined for extra energy savings and for the improvement of comfort conditions.

ECONOMIC CRITERIA ↔ ENERGY UPGRADING ↔ EDUCATIONAL CRITERIA

Food for thought: *"How does the lack of thermal comfort in schools affects learning?*
What does it cost to the Cyprus economy? "

Interreg Mediterranean TEESCHOOLS
Project co-financed by the European Regional Development Fund

Thank you!

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Twitter: cyenergyagency

ΕΝΕΡΓΕΙΑΚΟ ΓΡΑΦΕΙΟ

ΚΥΠΡΙΩΝ ΠΟΛΙΤΩΝ

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