



European Lighting Expert
Educational Objectives
Indoor Lighting
Outdoor Lighting





Preface

The European Lighting Expert is a cooperative project between the national lighting societies of Germany (LiTG), Austria (LTG), the Netherlands (NSVV) and Switzerland (SLG), paving the way for their future collaboration and common activities. The European Lighting Expert represents a responsible and competent handling of light. It is based on an internationally agreed level of education, which is defined in this document. A passed test qualifies for the registration as an ELE, which proves comprehension and application of this standard. The national lighting societies campaigning test and registration are obliged to this taxonomy and warrant its quality.

The national lighting societies are confident that the European Lighting Expert satisfies a large need to standardise the requirements for experts in indoor and outdoor lighting. The educational objectives of this taxonomy are comprehensive, interdisciplinary and on a high level. Passing an internationally supervised test qualifies for the registration as a European Lighting Expert. It proves comprehension of this standard and the ability to practically apply lighting knowledge and skills which are taught. The registration marks the expertise and qualification of a European Lighting Expert, it also displays a high level of education in enterprises employing European Lighting Experts.

LiTG, LTG, NSVV and SLG advocate the European Lighting Expert with their name and positive reputation in the lighting community. They guarantee credibility, reliability, trustability and responsibility of the registered lighting experts. The national lighting societies make every effort to communicate and successfully establish this educational standard.

Acknowledgements

We thank all the professionals involved for their altruistic and comprehensive contributions. They rendered possible a cogent foundation for this common project. We also would like to thank the lighting societies of Germany, Austria, the Netherlands and Switzerland, which wholeheartedly and with great pleasure supported this project. This taxonomy for the European Lighting Expert is the first step in a new way of international cooperation between the lighting societies.

Invitation

LiTG, LTG, NSVV and SLG encourage all other European lighting societies to contribute to this common project. In this way, the European Lighting Expert will be developing into the foundation of a high level European light culture.



Objective of this document

This document is to define the educational objectives of the European Lighting Expert in indoor and outdoor lighting. Persons audited according to these objectives are qualified to independently work in the fields of surveying, analysing, planning, consulting, installing and operating lighting installations in indoor or outdoor environments.

The target audience are persons willing to qualify as experts in indoor and/or outdoor lighting:

- employees and entrepreneurs of all business areas of the lighting branch (technology, planning, installation, facility management, marketing & sales, operations etc.)
- newcomers in lighting with a solid education in a different field (e.g. electricians, wholesalers, energy consultants and auditors etc.)
- people involved in lighting technology and design looking for further education (e.g. architects, engineers, planners, technical offices, builders, testing/certification institutes etc.)

Proof of qualification

Persons to register need profound knowledge about relations between perception, generation and effects of light as well as the related electrical engineering. They have to be able to apply this knowledge considering the relevant laws, standards and rules as well as ecological and economical aspects. They need to know up-to-date lighting equipment and lighting controls and how to use them. Proficiency about interfaces to adjacent fields like architecture, electrical engineering, ergonomics and ecology is mandatory. This enhances the ability to recognise lighting as multidisciplinary and its embedment in the environment.

The capability to think discretely and conceptualise interdisciplinary is essential to take proper decisions and act conveniently.



Taxonomy

It is not sufficient to only repeat memorized knowledge to succeed in a test qualifying for the European Lighting Expert in indoor or outdoor lighting. The educational objectives must be worked out by individual thinking and studying to achieve the necessary level of competence.

The educational objectives are classified into three levels of competence (after Bloom's wheel) which are necessary for the European Lighting Expert:

C1: Knowledge	Exhibit memory of learned materials by recalling facts, terms, basic concepts, and answers. <ul style="list-style-type: none">- Knowledge of specifics - terminology, specific facts used in lighting- Knowledge of ways and means of dealing with specifics - conventions, trends and sequences, classifications and categories, criteria, methodology- Knowledge of the universals and abstractions in lighting - principles and generalizations, theories and structures
C2: Comprehension	Demonstrate understanding of facts and ideas by organizing, comparing, translating, interpreting, giving descriptions, and stating the main ideas: Coping with issues and problems in lighting praxis with calculations, graphical presentations and explanations.
C3: Application	Using acquired knowledge. Solve problems in new situations by applying acquired knowledge, facts, techniques and rules in an unknown and new situation. Coping with complex problems as found in typical working routines, finding optimal solutions.

The difficulty increases from C1 to C3. The level to achieve in a specific subject is marked at the adequate position.

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Educational Objectives

1 Basic Knowledge		Outdoor	Indoor
1.1 Lighting Technology			
1.1.1 Scientific base			
	<i>Electromagnetic waves</i>	C1	C1
	<i>Light Sources</i>	C1	C1
1.1.2 Quantities and Units			
	<i>Spectral Sensitivity</i> <ul style="list-style-type: none"> • <i>Photopic</i> • <i>Mesopic</i> • <i>Scotopic</i> 	C2	C2
	<i>Luminous Flux Φ</i>	C3	C3
	<i>Solid Angle Ω</i>	C3	C3
	<i>Luminous Intensity I</i>	C3	C3
	<i>Illuminance E</i> <ul style="list-style-type: none"> • <i>Horizontal</i> • <i>Vertical</i> • <i>Cylindrical</i> 	C3	C3
	<i>Inverse square law</i>	C2	C2
	<i>Luminance L</i>	C3	C3
	<i>Luminous efficacy η</i>	C3	C3
	<i>Luminous Intensity Distribution</i>	C3	C3
	<i>Contrast rendering factor</i>	C2	C1
1.1.3 Light & Colour			
	<i>Colour and Spectrum</i>	C1	C1
	<i>Colour Temperature T_f</i>	C1	C2
	<i>CIE Colour Rendering Index R_a / CIE CRI</i>	C1	C2
	<i>Additive and subtractive colour mixing</i>	C2	C1
	<i>Colour Systems</i> <ul style="list-style-type: none"> • <i>Hue, Saturation and Brightness</i> • <i>CIE Chromaticity chart</i> • <i>Colour differences</i> 	C2	C1
1.1.4 Optic characteristics of materials			
	<i>Absorption</i>	C1	C1
	<i>Transmission</i>	C1	C1
	<i>Reflection</i>	C1	C1
	<i>Relationships</i>	C2	C2
	<i>Lambertian radiator, diffuse reflection</i>	C2	C2
1.1.5 Vision and Perception			
	<i>The Human eye</i>	C1	C1
	<i>Characteristics</i> <i>Sensitivity, adaptation, vision, visual acuity, accommodation, aberration, Non-image forming receptor</i>	C1	C1
	<i>Colour Perception</i> <i>Hue, Saturation and Brightness</i>	C1	C1
1.1.6 Effect on the Human			
	<i>Health aspects, psychologic effects, photobiological effects, Perception, Equality, emotional effect</i>	C1	C1
	<i>Light as a timer</i>	C1	C1
	<i>Light and working conditions</i>	-	C1
	<i>Dynamic lighting</i>	-	C1
	<i>Light therapy</i>	-	C1
	<i>Dynamic lighting in the work environment</i>	-	C1

1.1.7 Visual Disturbances			
	<i>Glare and gloss</i>	C2	C2
	<i>Veiling luminance</i>	C1	-
	<i>Physiological and psychological glare</i>	C2	C2
	<i>Disturbances from light sources, stroboscopic effect, flicker, electrode flicker</i>	C1	C1
1.2 Electrical Engineering			
1.2.1 Fundamentals			
	<i>Standards</i> <ul style="list-style-type: none"> • National standards • European standards 	C3	C3
	<i>Functioning of electricity</i> <ul style="list-style-type: none"> • Touch voltage • Error voltage 	C2	C1
	<i>Electrical networks</i>	C1	-
	<i>Electric safety, types of systems</i> <ul style="list-style-type: none"> • Safety precautions • Grounding, lightning protection • Safety categories 	C3	C2
	<i>Electrical, apparent, and reactive power</i> <ul style="list-style-type: none"> • Compensation • Power factor 	C2	C1
1.2.2 Technical Requirements			
	<i>General connect requirements</i> <ul style="list-style-type: none"> • Electrical distribution board • kWh meter • Steering 	C1	C1
	<i>Classification and types of security and possible choices</i>	C3	-
	<i>Cable diameter dimensioning</i> <ul style="list-style-type: none"> • Permissible cable length • Permissible voltage drop 	C3	C1
	<i>Cable conduction</i>	C1	C1
1.2.3. Hardware and software control of luminaires			
	<i>DALI</i>	C1	C3
	<i>1...10 Volt</i>	C1	C3
	<i>DMX</i>	C1	C3
1.2.4. Documentation			
	<i>Legislative/normative requirements</i> <ul style="list-style-type: none"> • Test requirements • Test intervals • Test size 	C1	C1
	<i>Electrical design documents and their content</i>	C1	C1
	<i>Installation manager</i>	C1	C1
	<i>Installation book</i>	C1	C1
1.3 Light Sources			
1.3.1 List of light sources			
	<i>Description electrical lamps, applicable lamp descriptions</i>	C1	C1
	<i>Typical indices light sources</i>	C1	C1
	<i>Lamp fittings</i>	C1	C1
	<i>Definitions lifetime of light sources (failure, luminous reflux)</i>	C1	C1
1.3.2 Temperature radiator			
	<i>Description electrical lamps, applicable lamp descriptions</i>	C1	C1
	<i>Typical indices light sources</i>	C1	C1
	<i>Lamp fittings</i>	C1	C1

	<i>Definitions lifetime of light sources (failure, luminous reflux)</i>	C1	C1
1.3.3 Low pressure discharge lamps			
<i>Development and functionality Spectrum Correlated Colour Temperature and colour rendering Lifetime (luminous reflux and failure) Temperature sensitivity Replacements Switching circuit Usage</i>	<i>Fluorescent lamps</i>	C2	C2
	<i>CFLs</i>	C2	C2
	<i>Natrium vapour low-pressure lamp</i>	C1	-
	<i>Induction lamp</i>	C1	C2
	<i>Cold cathode lamps</i>	-	C1
1.3.4 High pressure discharge lamps			
<i>Development and functionality Spectrum Correlated Colour Temperature and colour rendering Lifetime (luminous reflux and failure) Temperature sensitivity Replacements Switching circuit Usage</i>	<i>Natrium vapour high-pressure lamp</i>	C2	-
	<i>Mercury vapour high-pressure lamp</i>	C1	-
	<i>Halogen metal vapour high-pressure lamp</i>	C2	C2
1.3.5 Solid state light sources			
	<i>LED</i> <ul style="list-style-type: none"> • <i>White and monochromatic light</i> • <i>Development and functionality</i> • <i>Spectrum</i> • <i>Light colour and colour rendering</i> • <i>Lifetime</i> • <i>Temperature behaviour</i> • <i>Light source replacement</i> • <i>Switching circuits</i> • <i>Application</i> • <i>Binning, Mc Adams ellipse</i> • <i>System/ module, luminaire, indices</i> 	C2	C2
	<i>OLED</i> <ul style="list-style-type: none"> • <i>Development and functionality</i> • <i>Applications</i> 	C1	C1
1.3.6 Ballasts and Drivers for light sources			
	<i>Types, function and applications</i> <ul style="list-style-type: none"> • <i>Magnetic, electronic ballasts</i> • <i>Starter</i> • <i>Steering device</i> 	C3	C2
	<i>Security requirements</i> <ul style="list-style-type: none"> • <i>Types of protection</i> • <i>Spark suppression</i> • <i>Over voltage protection</i> 	C1	C2
	<i>Incandescent and halogen lamp</i>	-	C2
	<i>Natrium vapour low-pressure lamp</i>	C2	-
	<i>High-pressure discharge lamp</i> <ul style="list-style-type: none"> • <i>Natrium vapour lamp</i> • <i>Mercury vapour lamp</i> • <i>Halogen Metal vapour lamp</i> 	C1	C1
	<i>Induction lamp</i>	C1	C1
	<i>LED</i>	C2	C2

1.3.7 Energy labelling and certificates			
	<i>EU and national Directives and Policies</i>	C1	C1
	<i>Economical comparison of different types of light sources</i>	C2	C1
1.3.8 Recycling of lamps			
	<i>Recycling concepts</i>	C1	C1
	<i>Green energy, sustainability, resource issues</i>	C1	C1
1.4 Luminaires			
1.4.1 General			
	<i>Photometric influence of the mounting position</i> <ul style="list-style-type: none"> • Shade • Shape: technical/decorative • Reflector shapes 	C1	C1
	<i>Long term characteristics</i> <ul style="list-style-type: none"> • Enclosure material/compensation (corrosion properties) • closeness/ sealing systems • Shade (impact resistance. UV permanence) • Vibration behaviour (including fixation / support system etc.) • Temperature behaviour 	C2	C1
	<i>Reflector shapes</i>	C1	C1
1.4.2 Luminaire types			
	<i>Interior lighting</i> <ul style="list-style-type: none"> • Trough luminaires • Reflector luminaires • Grid luminaires • direct/ indirect luminaires • Radiator 		C1
	<i>Exterior lighting</i> <ul style="list-style-type: none"> • Street lighting luminaires • Spot lights • Direct-/indirect luminaires • Bollard • Recessed ground luminaires 	C1	
1.4.3 Luminaire specifications			
	<i>Photometric properties</i> <ul style="list-style-type: none"> • Luminous flux distribution, • Luminaire efficiency • Classification 	C2	C2
	<i>Unified Glare Rating (UGR)</i>		C1
	<i>Brightness class</i>	C1	-
	<i>Glare index class</i>	C1	
	<i>Safety requirements</i> <i>Safety classes (IPxx), safety features, over voltage protection, spark suppression, fire safety, explosion protection, ball sports protection, vandalism</i>	C1	C1
	<i>Required description on luminaire</i>	C1	C1
	<i>Cooling elements for LED luminaires</i>	C2	C2
	<i>Test Mark (ENEC, national Test Marks, ...)</i>	C1	C1
1.4.4 Standards			
	<i>Overview of EN 60598</i>	C1	C1

2 Lighting Design – Interior		Outdoor	Indoor
2.1 Lighting Design for Interior Spaces			
2.1.1 Fundamentals for Lighting Design			
	<i>Human needs</i> <ul style="list-style-type: none"> • wellbeing, • comfort, • work atmosphere, • ergonomics, • productivity, • light needs 	-	C1
	<i>Standards and guidelines</i> <ul style="list-style-type: none"> • EN 12464-1 • Other national standards 	-	C3
	<i>Project requirements</i> <ul style="list-style-type: none"> • Visual task • Aim/function of the space, application • Location of object to be lit • Local and climatological conditions • Space decoration, furniture • Space impression, atmosphere • Building requirements • Type/application of surrounding spaces • Environmental conditions • Choices of light sources • Technical descriptions 	-	C3
2.1.2 Prevention of projection errors			
	<i>Problem statement before start design process</i> <ul style="list-style-type: none"> • Delayed design process • Missing or incorrect detail descriptions • Specific spacious situations not taken into account • Situation electrical grid/ end groups 	-	C3
	<i>Problem statement during design process</i> <ul style="list-style-type: none"> • Reflection grading • Luminaires pattern • Classification of luminaires • Maintenance factor • Fixing height • Special luminaires 	-	C3
2.1.3 Lighting design considerations			
	<i>Dimensioning basics</i> <ul style="list-style-type: none"> • Illuminance • Grouping/steps illuminance • Uniformity of illuminances • Luminance distribution • Maintenance illuminance • Processing sketches for the architectural lighting design for daylighting and electric lighting 	-	C3
	<i>Glare limitation</i> <ul style="list-style-type: none"> • UGR-method 	-	C3
	<i>Optical impression</i> <ul style="list-style-type: none"> • Shadow, modelling • Correlated Colour Temperature • Colour rendering 	-	C3
	<i>Maintenance plan</i> <ul style="list-style-type: none"> • Maintenance factor (LLMF, LMF, LSF, RSMF) • Necessity replacement light source • Module replacement for LED • Luminaires (single and multiple replacements) • Period of usage • Switching circuits 	-	C3

2.1.4 Lighting Calculations			
	<i>Dimensioning of the lighting</i> <ul style="list-style-type: none"> • Environmental data • Maintenance values • Light sources data 	-	C3
	<i>Allocation</i>		
	<i>UGR- glare estimation</i> <i>UGR limits</i>	-	C3
	<i>Computer design</i> <ul style="list-style-type: none"> • Basic knowledge functionality • Applicable tools • Design possibilities 	-	C3
2.1.5 Selection of luminaire concept			
	<i>Lighting concept</i> <ul style="list-style-type: none"> • Direct lighting • Indirect lighting • Direct/indirect lighting • Additional lighting 	-	C3
	<i>Daylight</i> <ul style="list-style-type: none"> • Daylighting • Alternate lighting for daylight • Daylight control systems 	-	C2
	<i>Electric lighting</i> <ul style="list-style-type: none"> • General lighting • Workplace oriented general lighting • Workplace lighting 	-	C3
2.1.6 Economic considerations			
	<i>Type of costs</i> <ul style="list-style-type: none"> • Purchase costs • Planning costs • Installation costs • Operating costs • Conservation costs • Maintenance costs • Test costs • Energy costs • Cost development 	-	C2
	<i>Energy needs, national assumptions, Requirements</i>	-	C3
2.1.7 Daylight systems			
	<i>Daylight systems</i>	-	C1
2.1.8 Light management			
	<i>Open- & closed loop control concepts</i> <ul style="list-style-type: none"> • Concepts (DALI, DMX, 1-10 V, KNX etc.) • Daylight dependent control • Precision detector • BIM Data for AutoCAD or Sketch-up software 	-	C2
2.1.9 Documentation			
	<i>Design</i> <ul style="list-style-type: none"> • Test reports • Electrical indices • Test results, measurements (ET & LT) • Photometric data • Profitability calculations 	-	C3
2.1.10 Emergency Lighting			
	<i>Type of emergency lighting</i> <ul style="list-style-type: none"> • Replacement lighting • Safety lighting • Safety lighting for evacuation routes • Anti-panic lighting • Safety lighting for higher-risk workplaces 	-	C2

	<ul style="list-style-type: none"> Emergency lighting systems Decentralized systems Centralized systems Generator driven systems 	-	C1
	Security and rescue symbols	-	C2
	Photometric projection and legal principles, etc.	-	C2
	Overview standards <ul style="list-style-type: none"> EN 1838 EN 50171 EN 50172 EN 50272 EN 62034 EN 60598-2-22 Further national standards and recommendations 	-	C1
2.2 Execution and operation of interior lighting			
2.2.1 General Aspects			
	Design considerations <ul style="list-style-type: none"> Space impression Activities in the space Photometric qualitative properties Building perspectives Types of luminaires Transition point to other installations 	-	C3
	Design steps <ul style="list-style-type: none"> Gather guidelines Choice of light sources Choice of luminaires Calculations Sketches for daylight and electric lighting plans Determine type of luminaires Profitability calculations Safety considerations 	-	C3
2.2.2 Maintenance – Upkeep			
	Plan and realize light source replacements	-	C3
	Clean luminaires	-	C3
	Replacement of defective parts during period of usage.	-	C3
	Fault repair service	-	C1
	Required documentation	-	C3
2.2.3 Test and Inspection			
	Electrical test	-	C2
	Photometric test	-	C2
	Object test / inspection (stateless parts etc.)	-	C2
	Test documentation	-	C3
2.2.4 Work places			
	Requirements <ul style="list-style-type: none"> EN 12464-1 Further actual standards and recommendations 	-	C3
2.2.5 Gyms, Sport Halls			
	Special requirements <ul style="list-style-type: none"> EN 12464-1 EN 12193 Further actual standards and recommendations 	-	C3
2.3 Renovation of interior lighting			
2.3.1 Renovation Aspects			
	Principles <ul style="list-style-type: none"> Outdated lighting system Ergonomics 	-	C3

	<ul style="list-style-type: none"> • Potential energy savings • Economical • Capital destruction 		
	<i>Execution</i> <ul style="list-style-type: none"> • Visual task • Daylighting - usage • Profitability • Investment costs • Operating costs • Potential savings • Lighting concept • Type of lighting • Technical requirements • Alternate solutions • Registrations • Registration control 	-	C3
	<i>Sales areas</i> <ul style="list-style-type: none"> • Specific function of lighting • Basic design concept • Lighting concepts • Types of lighting for sales areas 	-	C3
2.3.2 Electrical engineering – special issues during renovation			
	<i>What is a substantial expansion?</i>	-	C1
	<i>Safety precautions</i>	-	C1
	<i>Test, analysis, documentation of file</i>	-	C3
	<i>Electrical dangers in outdated installations</i>	-	C1

3 Lighting Design – Exterior		Outdoor	Indoor
3.1 Lighting Design for Exterior Spaces			
3.1.1 Fundamentals for Lighting Design			
	<i>Legal principles</i> <ul style="list-style-type: none"> • Road safety commitments • Obligations road owners • Lighting obligations • Compensation for damages • Responsibility questions • Tolerance commitment 	C2	-
	<i>Aspects of urban planning</i> <ul style="list-style-type: none"> • Architecture • Urban furniture • Feelings of security / criminality 	C2	-
	<i>Street lighting standard EN 13201 + CIE 115 (ROVL 2014)</i> <ul style="list-style-type: none"> • Traffic definitions • Zoning / ranges • Traffic flows • Velocities • Risks • Quality determination • Lighting classes • Glare limitation • Physiological glare (TI-factor) • Psychological glare • S.P. Ratio 	C3	-
	<i>Conflict zones / meeting areas</i> <ul style="list-style-type: none"> • Pedestrian zones • Parking places • Pedestrian crossings • Roundabouts • Traffic lane distribution • Other conflict zones 	C3	-

	<i>Further national provisions / standards</i>	C1	-
3.1.2 Lighting design considerations			
	<i>Determination of lighting concepts</i> <ul style="list-style-type: none"> • <i>Choice of lighting situation</i> • <i>Choice of lighting classification</i> • <i>Determination of Correlated Colour Temperature</i> • <i>Determination of lighting geometry</i> 	C3	-
	<i>Dimension principles</i> <ul style="list-style-type: none"> • <i>Luminance</i> • <i>V-lambda (eye sensitivity curve)</i> • <i>General and longitudinal uniformity (luminance and illuminance)</i> • <i>Roadside factor (Edge Illuminance Ratio – EIR)</i> • <i>E-vert+1,5m-y</i> • <i>Luminance distribution</i> • <i>Illuminance (vertical, horizontal, cylindrical, semi-cylindrical)</i> 	C3	-
	<i>Developing maintenance plan</i> <ul style="list-style-type: none"> • <i>Maintenance factor / Required lamp replacements</i> • <i>Switching circuits</i> 	C3	-
3.1.3 Light management			
	<i>Open- & closed loop control concepts</i>	C3	-
	<i>Dimming on demand</i>	C2	-
	<i>Further possibilities</i>	C2	-
3.1.4 Choice of support system			
	<i>Support System</i> <ul style="list-style-type: none"> • <i>Type</i> • <i>Construction</i> • <i>Fixation possibilities</i> • <i>Fundaments</i> • <i>Static and dynamic calculations</i> • <i>Material properties</i> • <i>EN 40 (Requirements for lighting poles)</i> 	C2	-
3.1.5 Ecologic considerations for the design			
	<i>Energy use (dimming etc.)</i>	C3	-
	<i>Emission/Immission</i> <ul style="list-style-type: none"> • <i>Humans: e.g., sleep disorder</i> • <i>Animals/Fauna: insects, birds, amphibians</i> • <i>Obstrusive light / Light pollution</i> 	C3	-
3.1.6 Pitfalls during the project organization			
	<i>Problems during design process</i> <ul style="list-style-type: none"> • <i>Incorrect assignment formulation</i> • <i>Delayed process start</i> • <i>Insufficient or incorrect detail/analysis</i> • <i>Missing/incorrect traffic data</i> • <i>Insufficient knowledge of street situations, material, and environmental aspects</i> • <i>Electrical supply problems</i> • <i>Insufficient planning</i> 	C3	-
	<i>Problems in design process</i> <ul style="list-style-type: none"> • <i>Traffic parameters</i> • <i>Ground material properties</i> • <i>Danger zones</i> • <i>Luminaire arrangements</i> • <i>Luminaire classification</i> • <i>Maintenance factor</i> • <i>Mapping phase lighting geometry</i> 	C3	-

	<ul style="list-style-type: none"> • <i>Special application requirements</i> 		
3.1.7 Lighting calculations			
	<i>Dimensioning of Lighting</i> <ul style="list-style-type: none"> • <i>Street data (subterranean, areas)</i> • <i>Traffic data</i> • <i>Maintenance value</i> • <i>Light sources data</i> • <i>Luminaires data</i> • <i>Application = lighting geometry</i> 	C3	-
	<ul style="list-style-type: none"> • <i>TI- Glare analysis/ Limit</i> • <i>Illuminance classes</i> • <i>Glare indices</i> 	C3	-
	<i>Computer designs</i> <ul style="list-style-type: none"> • <i>Basic functionality</i> • <i>Common tools</i> • <i>Possible designs</i> 	C3	-
3.1.8 Economic aspects			
	<i>Type of costs</i> <ul style="list-style-type: none"> • <i>Purchase costs</i> • <i>Design costs</i> • <i>Installation costs</i> • <i>Operating costs</i> • <i>Conservation costs</i> • <i>Maintenance costs</i> • <i>Test costs</i> • <i>Storage costs</i> • <i>Energy costs</i> 	C2	-
	<i>Lifecycle cost calculations</i>	C2	-
	<i>Payback time, ROI (Return of Investment)</i>	C2	-
	<i>Type of financing</i> <ul style="list-style-type: none"> • <i>Contracting</i> 	C2	-
	<i>Energy needs</i> <ul style="list-style-type: none"> • <i>National challenges/requirements</i> 	C3	-
3.1.9 Documentation			
	<ul style="list-style-type: none"> • <i>Drawings</i> • <i>Photometric data</i> • <i>Electrical indices</i> • <i>Test reports, measurements (ET & LT)</i> • <i>Conservation and maintenance plans</i> • <i>Profitability calculations</i> 	C3	-
3.2 Lighting Design for Exterior Spaces			
3.2.1 General considerations for the implementation			
	<i>Design considerations</i> <ul style="list-style-type: none"> • <i>Deviating requirements</i> • <i>Photometric quality characteristics</i> • <i>Building principles</i> • <i>Danger zones</i> • <i>Types of luminaires</i> • <i>Transition point to installation</i> 	C3	-
	<i>Design steps</i> <ul style="list-style-type: none"> • <i>Gathering principles</i> • <i>Choice of light sources</i> • <i>Choice of luminaires</i> • <i>Calculations</i> • <i>Determination of type/application of lighting</i> • <i>Profitability</i> • <i>Safety requirements</i> • <i>Completion in accordance with customer's requirements</i> 	C3	-
3.2.2 Maintenance			
	<i>Plan and realize replacement of light sources</i>	C3	-
	<i>Clean luminaires - inside/outside</i>	C3	-

	<i>Replacement of defective parts during period of use</i>	C3	-
	<i>Maintenance plan – log</i> <ul style="list-style-type: none"> • <i>Cleaning</i> • <i>Group replacement, spot replacement</i> • <i>Contract and warranty</i> 	C3	-
	<i>Fault repair service</i>	C1	-
	<i>Required test documentation</i>	C3	-
3.2.3 Testing and Inspecting			
	<i>Electrical test (maintenance, inspection)</i>	C2	-
	<i>Photometric test</i>	C2	-
	<i>Static test – support parts (maintenance, inspection)</i>	C2	-
	<i>Object test/inspections (Icicles, stateless parts etc.), Electrical test</i>	C2	-
	<i>Test documentation</i>	C3	-
3.2.4 Light management			
	<i>Test and adaptation of lighting control system in accordance with user requirements</i>	C3	-
3.2.5 Exterior work places			
	<ul style="list-style-type: none"> • <i>Requirements in accordance with NEN-EN 12464-2</i> • <i>Deviations with respect to the NEN-EN 13201</i> • <i>Further actual standards/recommendations</i> 	C3	-
3.2.6 Exterior sport arenas			
	<i>Requirements in accordance with NEN-EN 12193</i>	C3	-
	<i>Specific requirements (e.g., TV recordings)</i>	C3	-
	<i>Typical luminaires / spot lights</i>	C1	-
	<i>Emergency lighting – NEN-EN 1838 Safety lighting – NEN-EN 12193</i>	C1	-
3.2.7 Illumination of objects			
	<i>Buildings</i> <ul style="list-style-type: none"> • <i>Facades</i> • <i>Advertising columns, panels</i> • <i>Effect lighting</i> 	C3	-
	<i>Projection requirements</i>	C1	-
	<i>Light imissions</i> <ul style="list-style-type: none"> • <i>Sky luminance and glare</i> • <i>Glare</i> • <i>Environment and residents</i> 	C1	-
	<i>Deliberate use of light – shadow – colour</i>	C1	-
	<i>Cleaning, precise adjustments</i>	C1	-
3.2.8 Tunnel lighting			
	<i>National standards and recommendations</i>	C1	-
3.2.9 Active markers			
	<i>LEDs in road</i>	C1	-
3.2.10 Advertisement lighting			
	<i>Rural environment</i>	C1	-
	<i>Urban environment</i>	C1	-
	<i>Traffic function</i>	C1	-
3.3 Renovation of Exterior Lighting Installations			
3.2.1 Maintenance aspects			
	<i>Principles</i> <ul style="list-style-type: none"> • <i>Outdated lighting system</i> • <i>Limited budget, high costs</i> 	C3	-

	<ul style="list-style-type: none"> • <i>New light sources, respectively lighting technologies</i> • <i>Potential energy savings</i> • <i>Profitability</i> • <i>Sustainability aspects</i> 		
	<i>Roadmap</i> <ul style="list-style-type: none"> • <i>Improvements in status quo recording, requirements, and development of ideas</i> • <i>Lighting technology</i> • <i>Electrical engineering</i> • <i>Support systems</i> • <i>Judicial aspects</i> • <i>Potential savings, operating costs</i> • <i>Profitability, payback time</i> • <i>Lighting concept</i> • <i>Type & requirements</i> • <i>Registrations</i> • <i>Registration control</i> 	C3	-
3.3.2 Electrical engineering – special issues during renovation			
	<i>What is a substantial expansion?</i>	C1	-
	<i>Safety precautions</i>	C1	-
	<i>Test, analysis, documentation of file</i>	C1	-
	<i>Electrical dangers in outdated installations</i>	C1	-

4 Photometric Measurements		Outdoor	Indoor
4.1 Fundamentals			
	<i>Photoelectric receivers</i>	C1	C1
	<i>Influence of precision on the design</i>	C1	C1
	<i>Measurements instruments for practice</i> <ul style="list-style-type: none"> • <i>Illuminance measurement instrument (Lux meter)</i> • <i>Luminance measurement instrument/camera</i> • <i>Further measurement instrument (e.g., multi meter, thermometer)</i> 	C1	C1
	<i>Standards and guidelines</i>	C1	C1
4.2 Measurements of luminaires			
	<i>Luminous intensity distribution</i>	C1	C1
	<i>Measurement of luminance</i>	C1	C1
	<i>Measurement of luminous flux</i>	C1	C1
	<i>Determination of light output ratio</i>	C1	C1
4.3 Measurements – Interior Lighting			
	<i>Illuminance measurements</i> <ul style="list-style-type: none"> • <i>Measurement grid</i> • <i>Luminance measurements</i> • <i>Local illuminance</i> • <i>Mean illuminance</i> • <i>Reflections of surrounding planes</i> • <i>Voltage on luminaire</i> • <i>Temperature close to light source</i> • <i>Empty spaces</i> • <i>Furnished spaces</i> 	-	C2
	<i>Measurement analyses</i> <ul style="list-style-type: none"> • <i>Measurement protocol</i> • <i>Elaboration models</i> • <i>Accuracy of measurements</i> • <i>Assessment</i> 	-	C2

4.4 Measurements – Exterior Lighting			
	<i>Execution of measurements</i> <ul style="list-style-type: none"> • <i>Measurement grid</i> • <i>Measurements illuminance & luminance</i> • <i>Physical measurements of luminance</i> • <i>Determination of light pollution (e.g., TI, VW value, GRL, I-value, and lux value)</i> • <i>Assessment subterranean track</i> 	C2	-
	<i>Measurement analyses</i> <ul style="list-style-type: none"> • <i>Measurement protocol</i> • <i>Calculation of not-directly measurable quality indices (e.g. uniformity, glare index)</i> • <i>Elaboration models</i> • <i>Accuracy of measurements</i> • <i>Assessment (also in comparison with calculations)</i> 	C2	-