# QUALITY IN ENGINEERING EDUCATION

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**Instituto Superior de Engenharia do Porto**

# TO SAY WHAT I AM GOING TO SAY…

① **A good moment and reason to revisit Bologna!**
  - ① **TRUST is the name of the game!**
  - ① **Structure and substance**

② **Qualifications Frameworks – a three layer concept**
  - ② **Meta Frameworks – QF-EHEA, EQF-LLL**
  - ② **Sectoral Frameworks – EUR-ACE**
  - ② **Descriptors at branch level – The Case Study of EFCE WP on Education**

③ **Quality Assurance**
  - ③ **General QA vs. Field Specific QA Models**
  - ③ **The EUR-ACE accreditation system**

④ **Concluding Notes**

# EUROPEAN SEARCH FOR A NEW, MORE COMPETITIVE, MODEL FOR DEVELOPMENT, WITH THREE VISIBLE DIMENSIONS

- **Back in the last quarter of the XX Century – anticipating the future**

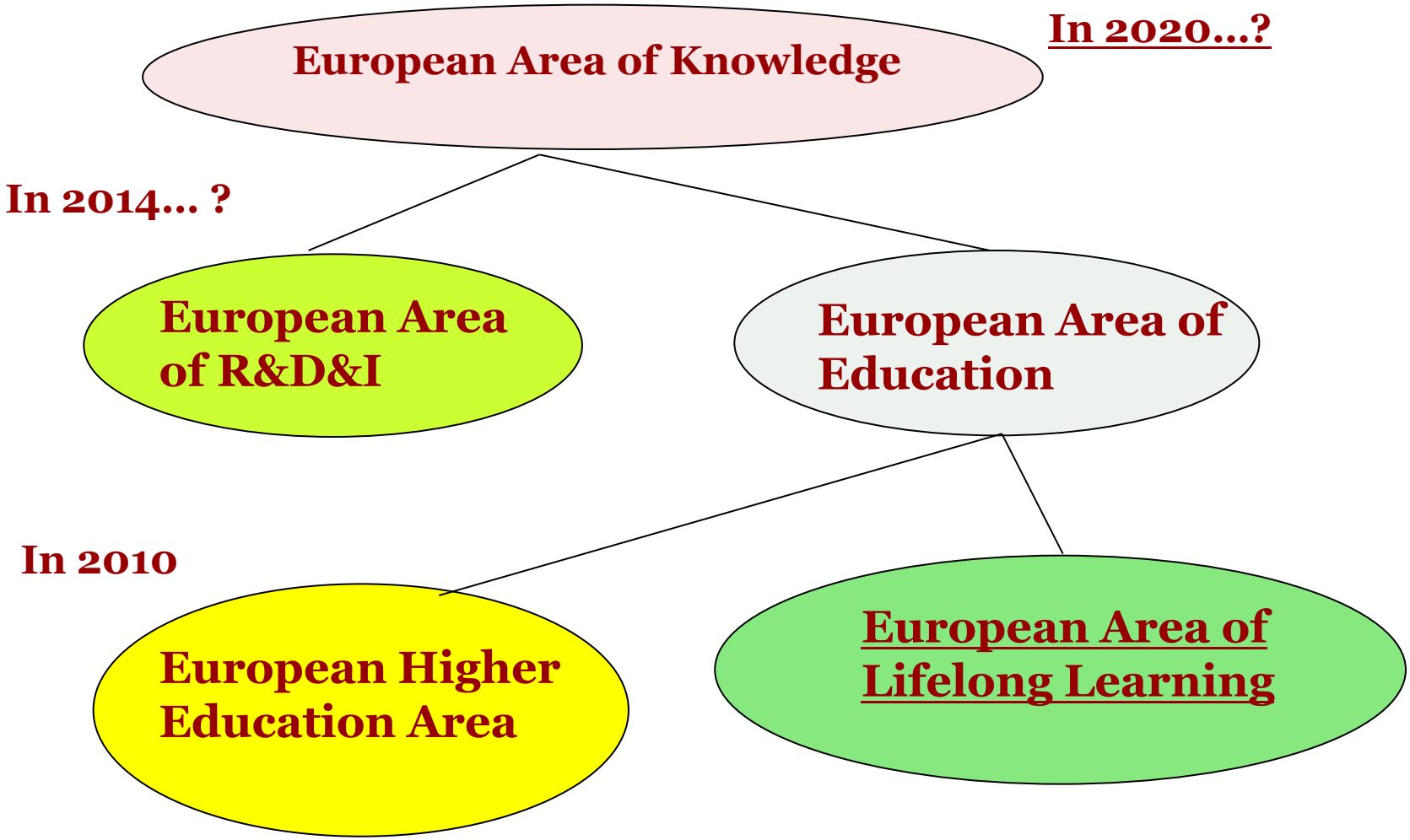
- **A strategy based on Knowledge and Transnational Cooperation, where we can recognise –**

  - **The Economy Dimension –**
    - **Including the movement that converged in the creation of the EURO**

  - **The Social Dimension –**
    - **Still in line with the European Social Model of the post-war time…**

  - **The Knowledge Society Dimension –**
    - **Identified with the Bologna Process and the creation of the European Area of Knowledge**

# The European Area of… Knowledge… Officially launched on 11-12 March 2010, in Budapest-Vienna - Still under construction… till 2020…



# The Core of the Bologna Reforms
# Keywords characterizing Structural Issues

- **The name of the game is BUILDING TRUST**
- **TRUST GOES WITH - COOPERATION and MOBILITY**
  - **MOBILITY AND COOPERATION require professional recognition**
  - **Professional recognition requires TRUST**
  - **TRUST requires transparency and readability of structures and professional qualifications**
- **All is achieved through:**

**COMPARABLE QUALIFICATIONS FRAMEWORKS and**

**RECOGNISED QUALITY ASSURANCE PROCEDURES**

# From Bologna to Budapest-Vienna... and beyond
# Characterizing the Process Today

- **Policy areas**
  - **Including great concern with the threat of 'Education without Boundaries'**
- **Structural organization issues**
- **The Substance – academic issues**

# From Bologna to Budapest-Vienna … and beyond
# The Structure - action lines and instruments for action

- ✓ **Degree Structure –**
  - **Based on recognised QUALIFICATIONS FRAMEWORKS**
- ✓ **A System to measure work and OUTCOMES**
  - **The ECTS credit and accumulation system**
- ✓ **A way of documenting qualifications**
  - **The DIPLOMA SUPPLEMENT**
- ✓ **A System to guarantee transparence**
  - **Building accepted QUALITY ASSURANCE procedures**
- ✓ **A System for recognition of qualifications**
  - **OVERCOMING DIFFICULTIES posed by the diversity of 'recognition cultures'**

# From Bologna to Leuven/Louvain-la-Neuve… and beyond
# The Substance - the latecomer in the Bologna Process…

- **Changes to a large extent still to occur**
  - **New contents… closer to more immediate Societal concerns**
  - **New programme structures, linked to a concept of lifelong Learning**
  - **New Methods – change from**
    - ✓ **Teacher-Centred to Student-Centred methodologies**
    - ✓ **Teaching based on Teacher Inputs to Learning Centred in well defined objectives – Learning Outcomes**
    - ✓ **Teaching Times to Student Workloads required to achieve desired Learning Outcomes**
- **The third wave – Pedagogical qualification of 'Faculty'**
- **New tools for distance and cooperative learning**

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② **Descriptors at branch level – The Case Study of EFCE WP on Education**

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③ General QA vs. Field Specific QA Models

③ The EUR-ACE accreditation system

④ Concluding Notes

# Qualifications Frameworks
# The different layers – Who does what…

- **High level descriptors – Meta Frameworks**
  - **Characterized at institutional level of governments and stakeholders**
  - **They represent the 'legal crust' and the basis for National Qualifications Frameworks**
- **Complemented by Sectoral descriptors**
  - **By area and specialty**
  - **In close cooperation with higher education institutions and professional associations**
  - **In transnational cooperation**
  - **They represent Bologna in practice**
- **Complemented by descriptors at branch level**
  - **Typically developed in Education Working parties and Academic Consortia, at European Level, or within regulatory bodies at national level**
  - **They are the basis for credibility of the whole system**

# Three major documents in this framework of development I – The Bergen Declaration within the Bologna Process (I)

- **The Bergen Communiqué signed by Ministers of Education of 45 Countries, on May 20, 2005**
  - **Framework for qualifications comprising three main cycles and a short cycle**
  - **Standards and guidelines for quality assurance in the EHEA**
    - **A model for peer review of quality assurance agencies on a national basis,**
    - **European register of quality assurance agencies based on national review.**
  - **Recognition of degree and study periods**
    - **Recognition of foreign qualifications and prior learning,**

# QF-EHEA - Qualifications Framework for the European Higher Education Area (Bergen 2005)

- A degree structure with **three main cycles and a short cycle** within or linked to the First Cycle
- Adopts the **Dublin Descriptors** developed by the **Joint Quality Initiative Group** as the cycle descriptors, characterizing levels to be attained in
  - ***knowledge and understanding***
  - ***applying knowledge and understanding***
  - ***making judgements***
  - ***communication***
  - ***Learning skills***
- **These are high level broad descriptors that will have to lead to more specific descriptors in each area or specialty within a given area**

# EQF-LLL - The European Qualifications Framework for Lifelong Learning

- **Approved by the Parliament and the Council of the European Union on April 23, 2008**
- **Adopts 8 levels of qualifications characterized in terms of**
  - ***Knowledge***
  - ***Skills***
  - ***Competences***
- **Establishes a link of compatibility with the Framework for Qualifications of the European Higher Education Area**

# Relevance of Sectoral and/or Curriculum Frameworks Taken from the Leuven/Louvain-la-Neuve Communique 29 April 2009

"...

Curricular reform will thus be an ongoing process leading to high quality, flexible and more individually tailored education paths.

Academics, in close cooperation with student and employer representatives, will continue to develop learning outcomes and international reference points for a growing number of subject areas

..."

# The EUR-ACE Sectoral Framework and Accreditation System

- **European Project that aimed at establishing an European System for Qualification of Engineering Education programmes**
  - ✓ **14 European Institutions, among them "Ordem dos Engenheiros – Engineers Portugal"**
  - ✓ **FEANI, SEFI, CESAER, EUROCADRES, ENQHEEI, ASIIN, CTI, IEI, CoPI, UNIFI, OE, UAICR, RAEE, EC-UK**
- **First Phase for setting the standards, supported by the European Commission (DG EaC) within SOCRATES and TEMPUS programmes; Concluded in 2005**
- **Second Phase for implementation, supported by the European Commission (DG EaC) within SOCRATES and TEMPUS programmes; concluded in 2008**

# The EUR-ACE Sectoral Framework and Accreditation System
## Knowledge and Competence areas

☞ **Programme Outcomes that must be satisfied**

- **6 areas of competences are defined**
  - ✓ **Knowledge and Understanding**
  - ✓ **Engineering Analysis**
  - ✓ **Engineering Design**
  - ✓ **Investigations**
  - ✓ **Engineering Practice**
  - ✓ **Transferable (personal) Skills**

- **For each category, the EUR-ACE Framework Standards list the expected Programme Outcomes of First Cycle and Second Cycle Studies**

# EUR-ACE Implementation

- **The EUR-ACE project has lead to the creation in 8 February 2006 of an European Association**
  - ✓ **The ENAEE – European Network for Accreditation of Engineering Education – www.enaee.eu**

- **The ENAEE is responsible for maintaining and awarding the EUR-ACE label**

# EUR-ACE ACCREDITED AGENCIES

**GERMANY** - ASIIN– Fachakkreditierungsagentur für Studiengänge der Ingenieurwissenschaften, der Informatik, der Naturwissenschaften, und der Mathematik e.V.

**FRANCE –** CTI – Commission des Titres d'Ingénieur.

**UK** - Engineering Council

**IRELAND –** Engineers Ireland

**PORTUGAL –** Ordem dos Engenheiros

**RUSSIA –** AEER – Association for Engineering Education in Russia.
**TURKEY –** MÜDEK – Association for Evaluation and Accreditation of Engineering Programmes.

**ROMANIA** – ARACIS – The Romanian Agency for Quality Assurance in Higher Education -

**ITALY –** QUACING - Agenzia per la Certificazione di Qualità e l'Accreditamento EUR-ACE dei Corsi di Studio in Ingegneria

**POLAND** – KAUT - Komisja Akredytacyjna Uczelni Technicznych,

# Qualifications Frameworks and Quality Assurance – What is equal, what is different
## QFs and the EUR-ACE System

| Bologna QF-EHEA CYCLES | European Union EQF-LLL LEVELS | EUR-ACE |
|---|---|---|
| Third Cycles | Level 8 | |
| Second Cycles | Level 7 | Second Cycles |
| First Cycles | Level 6 | First Cycles |
| Short Cycles Linked to or Within First Cycles | Level 5 | |

# Descriptors at Branch/Programme Level

## EXAMPLES AND CASE STUDIES COMING FROM THE CHEMICAL ENGINEERING AREA

- **The Recommendations of the WPE-EFCE – Working Party on Education – European Federation of Chemical Engineering (2010)**
- **The VDI-GVC Recommendation for Chemical and Processing Engineering (2008)**
- **The CHEMPASS Project (2006-2009) – that aimed at identifying relevant general and specific Learning Outcomes for Chemical Engineering Programmes**

# Descriptors at Branch/Programme Level Recommendations of the WPE-EFCE (I)

- **WPE-EFCE – Working Party on Education – European Federation of Chemical Engineering**

- ✓ **Currently with 41 members, representing 26 Countries**

- ✓ **Developed and published in 2010 a set of recommendations of core curriculum for chemical engineering – contents and methodologies**

- ✓ **See EFCE Site and Bologna Recommendations (2010) at**

  **http://www.efce.info/Bologna_Recommendation.html**

# Descriptors at Branch/Programme Level Recommendations of the WPE-EFCE (II)

- These recommendations cover
  - Learning outcomes
    - ✓ Adopting the EUR-ACE Framework Standards for Accreditation of Engineering Education
  - Achieving the learning outcomes
    - ✓ Core curriculum
    - ✓ Teaching and learning
    - ✓ Industrial experience
    - ✓ Review of the educational process
    - ✓ Student assessment

# Descriptors at programme level
# Recommendations of the WPE-EFCE (III)

- **Using as reference accumulated knowledge, competences and skills after a Second Cycle in Chemical Engineering**

⇩

- **A minimum dimension is proposed to**
  - ✓ **Basic sciences, enlarged with life sciences**
  - ✓ **Chemical engineering sciences**
  - ✓ **Chemical engineering core**
    - ➢ **With engineering design,**
    - ➢ **With a dissertation for training R&D&I,**
    - ➢ **With diverse profiles through electives and external training.**

# Descriptors at Branch/Programme Level
# Examples of Recommendations of the WPE-EFCE (I)

***First Cycle Chemical Engineering programme outcomes***

**After graduation, a first cycle degree chemical engineer should fulfill the following qualifications:**

**Knowledge and Understanding**

- ✓ **The graduates have acquired basic knowledge of mathematics, physics, chemistry and biology which enables them to understand the phenomena which occur in the field of chemical engineering.**
- ✓ **They have acquired the fundamental principles of chemical engineering for the modelling and simulation of chemical reactions and (bio)molecular processes, of energy, mass and momentum transport processes, and of separation processes**
- ✓ **They are familiar with the basic principles of measurement techniques and control.**

# Descriptors at Branch/Programme Level
# Examples of Recommendations of the WPE-EFCE (II)

***Second Cycle Chemical Engineering programme outcomes***

After graduation, a first cycle degree chemical engineer should fulfill the following qualifications:

☞ Knowledge and Understanding

✓ The graduates have acquired extensive and profound knowledge of mathematics, chemical engineering and other sciences which enable them to carry out scientific work and to act responsibly in their professions and in society. They are aware of new developments in their field.

==========

☞ **The EFCE expects that the final outcomes of second cycle ("master's") degree programme to be (at least) equivalent to those of traditional long-cycle (4,5-5 years) programmes**

# Descriptors at Branch/Programme Level
# Examples of Recommendations of the WPE-EFCE (III)

- **The core curriculum proposed covers only approx. two thirds of a first and a second level degree study**
- **Tipically a first cycle ("bachelor's") degree course will contain 20-30 % science courses, 40-50 % engineering courses, and up to 10 % non-technical topics.**
- **The core recommended for First Cycles gives a science content of 25 %, an engineering content of 36 %, and a non-technical content of 6 % of the total study (180 credits), leaving one third to deeper coverage of some of topics specific of a given course.**
- **The core curriculum proposed for Second Cycle ("master") studies makes up 63 % of the total study (of 120 credits), leaving 37% for additional specialization and broadening.**

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# General Quality Assurance Approaches
# Main Documents and Milestones

- **Standards and Guidelines for Quality Assurance in the European Higher Education Area (ESG), Bergen 2005**

- **The European Quality Assurance Register (EQAR), London 2007**
  - **Formally set on March 4, 2008**

- **Process led by the Council of Europe, catalysing the approval of National Qualifications Frameworks**

- **Creation of National Accreditation Agencies that are expected to register with EQAR**

# Quality Assurance in Engineering
# Issues leading to Field-Specific QA Systems

- Quality Assurance systems should include clear and measurable objectives and standards, associated to an accepted QF.

- **The understanding by all stakeholders of academic degrees and related specific knowledge, competences and skills of their graduates is essential for both internal and external evaluation and for recognition.**

- This means that we have to develop and implement field-specific strategies and methodologies for QA that must be supported by sectoral and branch specific descriptors of qualifications.

# EUR-ACE
# Accreditation System of Engineering Education

- **The word "accreditation" is employed as linked to a field-specific QA approach, in which the aims and contents of the educational programmes are to be specified:**

  **"Accreditation of an engineering educational programme is the primary result of a process used to ensure the suitability of that programme as the entry route to the engineering profession."**

- **Hence, sectoral and branch specific descriptors of outcomes, applied in combination with the ESG, should lead to "pre-professional accreditation" and should support Mutual Recognition Agreements for academic and/or professional purposes.**

# TO SAY WHAT I HAVE SAID…

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# Qualifications Frameworks and Quality Assurance

- **Frameworks must be considered at different levels – they must be compatible and easily articulate**
- **National Frameworks are the reference,**
  - **It is clear that they must be in substantial conformity with Meta Frameworks at all levels developed within the Bologna Process or other transnational cooperation**
- **Quality Assurance procedures should**
  - **Include criteria that are in substantial conformity with accepted descriptors at meta, sectoral and syllabus level**

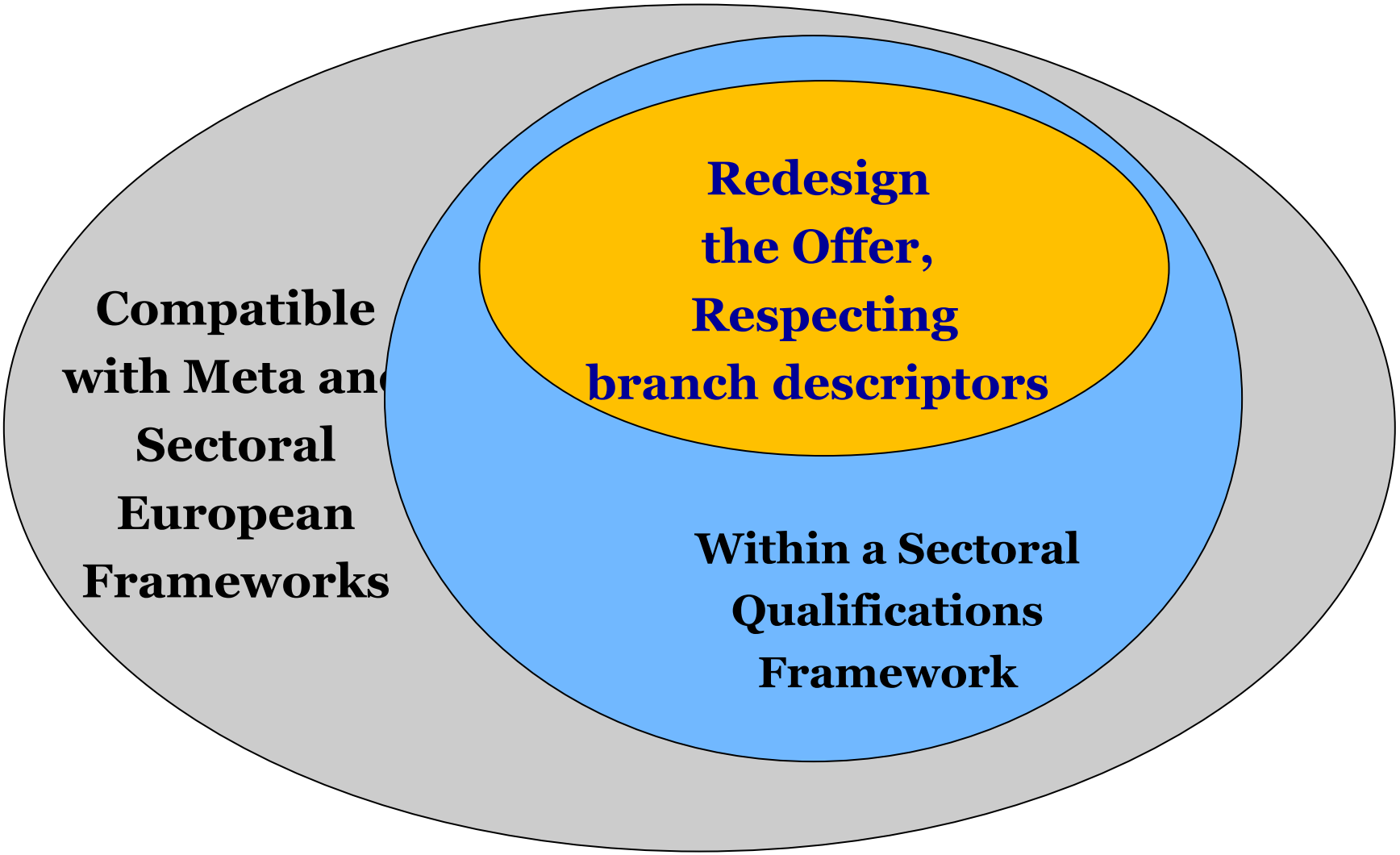
# BRANCH LEVEL DESCRIPTORS AS PART OF A THREE-LAYER CONCEPT FOR QF

- **At branch level,** recommendations, descriptors, reference points and tools for characterizing degree programmes should be freely developed through institutional co-operation

- **Within diversity, curricula and module syllabus should be designed** with reference to such agreed recommendations or descriptors of learning outcomes at high level, sectoral level and branch level

- The aim is to increase transparency in order to
  - **throw down barriers of recognition**
  - **promote co-operation, namely through joint degrees**
  - **increase mobility of students and staff**

# BRINGING BOLOGNA INTO PRACTICE



# BRINGING BOLOGNA INTO PRACTICE

- **For some countries, structural work is not yet finished…**

✓ **Defining NQF compatible with EQF**

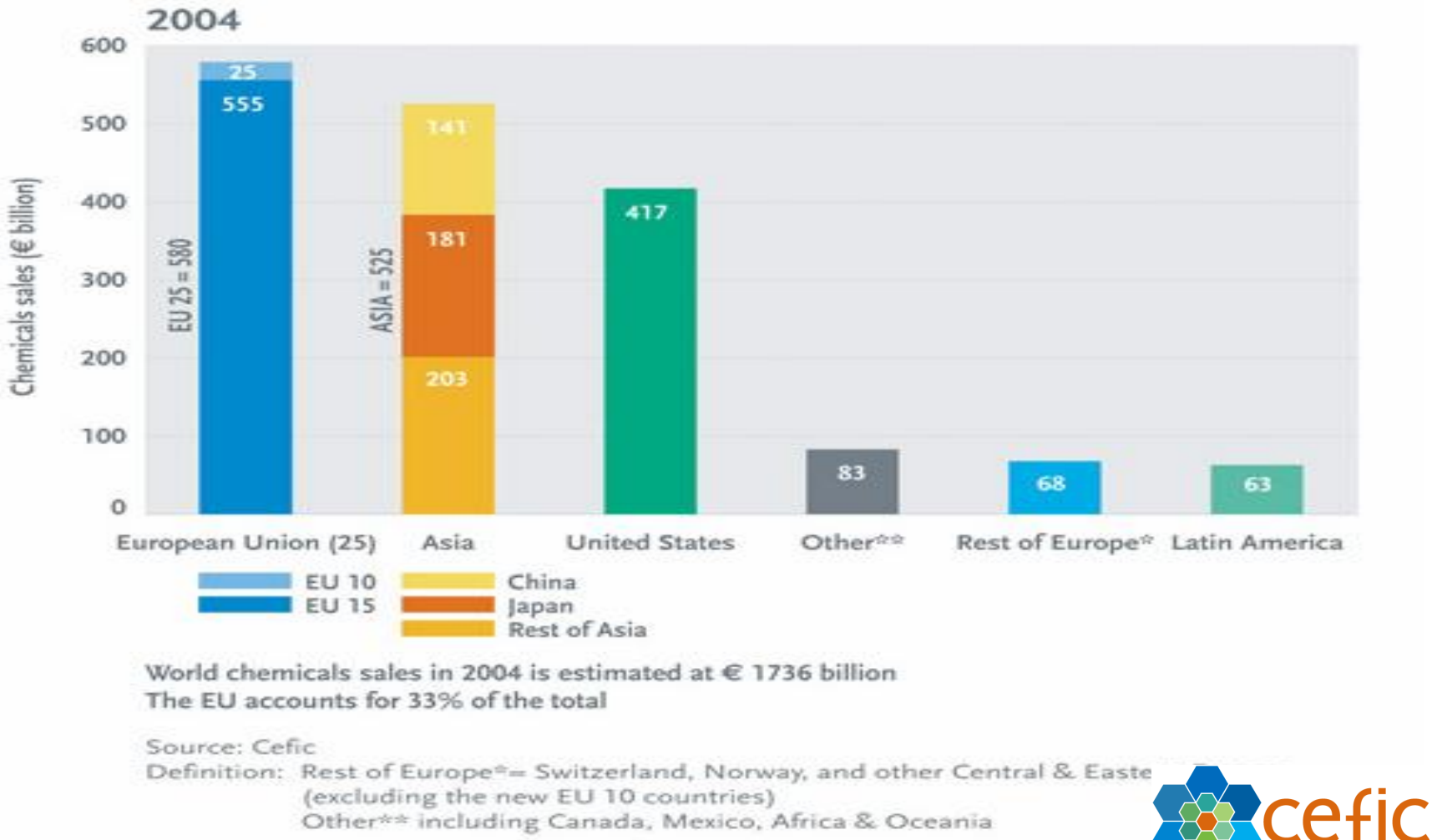
✓ **Characterizing the programmes through ECTS – Workload plus Outcomes**

✓ **Re-doing of all modules within this new framework**

✓ **Giving evidence that approved Learning Outcomes are achieved…..**

- **Or simply, bringing Bologna into practice…**
- **This requires full involvement of Academics**

# Life Today...
# III - Just an Example of World Competition
## Geographic breakdown of World chemicals sales,
## CEFIC F&F2004



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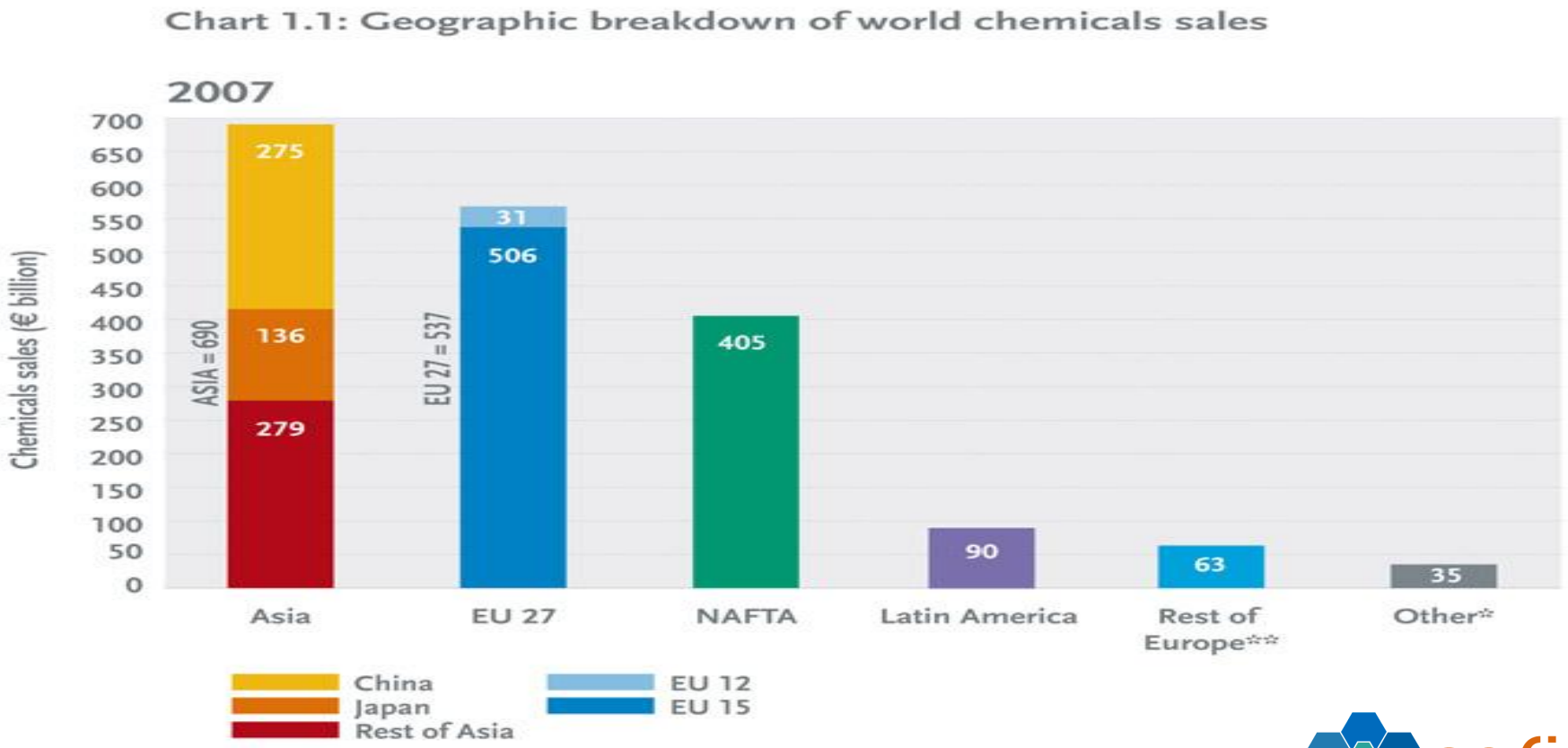

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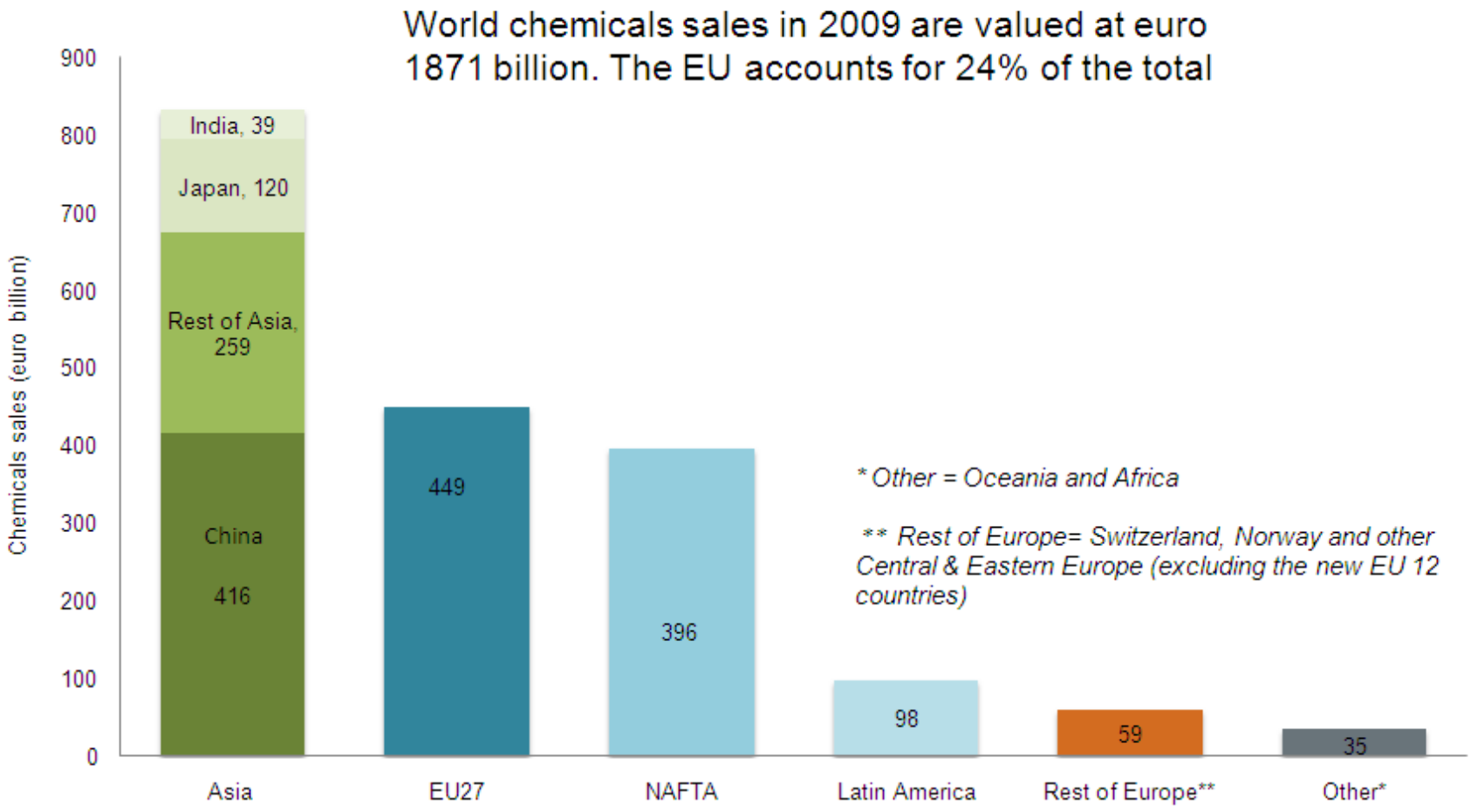
## CEFIC F&F2009



# LIFE OVER THE PAST 30 YEARS
# DRIVING FORCES FOR CHANGES

- **Last quarter of the 20th Century – Intense search of new routes for Europe and for the role of Europe in the World, driven by**
  - **Progress observed in Science and Technology, namely**
    - **in digital systems and communications**
    - **in health and life sciences**
  - **Political changes that took place in Europe**
  - **Expectations and demands of Society**
    - **Education for All**
    - **Quality requirements – The "Comfort Society"**

# Life over the past 30 years
# Driving forces for changes

- **Economy and market forces - driving force of Today's Societies**
- **The computer and communications era - dramatic changes of the concepts of time and space - globalisation**
- **Decreasing demogrqaphy and the increase of Expectation of Life – Social sustainability**
- **Sharp increase in standards and competition - Worldwide and within the European Space**
- **The need for mass education policies**
- **Significant change in the concepts of individual career management**
- **Job market and opportunities - wider than ever**

# BOLOGNA REFORMS
# ISSUES CONCERNING POLICY AREAS

- ✓ **From a social and economical point of view – to guarantee development and competitiveness through –**
  - **The increment of transnational cooperation and mobility, both in higher education and in R&D**
- ✓ **From a more political point of view –**
  - **To guarantee the Social Dimension**
  - **To promote Employability**
  - **To promote the External Dimension of the European model**
  - **To meet the Demographic Challenge**
  - **To meet the chalenges posed by Global Competition - 'Borderless Higher Education Market'**

# The EUR-ACE Sectoral Framework and Accreditation System
# Programme Assessment Procedures

☞ **Programme Assessment Procedures should include clear information and evidence on the following components:**

- ✓ Needs, objectives and outcomes
- ✓ Educational process
- ✓ Resources
- ✓ Assessment of the educational process
- ✓ Management system

☞ **In this context 'the criteria to be assessed' and the associated 'requirements' in the form of questions, valid for both FC and SC programmes should be addressed when assessing an engineering programme on education**

# Three indicators of relevance

## II – Report on progress in quality assurance in higher education (Text with EEA Relevance), European Commission, Brussels, 21.9.2009 COM(2009) 487 final

**Pg. 9:**
**Good practice**

**The EUR-ACE label in engineering exists at the bachelor and master level. Standards were defined at European level, but are applied through national quality assurance agencies that are authorised to issue EUR-ACE "labels" together with their national accreditation. Several hundred labels have already been awarded, but they are still available from only seven National agencies**

# Quality Assurance in Engineering
# Global vs. Field Specific Systems

- The issue is not to abandon "general" QA approaches, that lead to a relevant evaluation of the educational process, but rather to understand the relevance of "field-specific" QA systems

- **"Field-specific" QA systems accentuate the need for aligning the goals of educational programmes with the expectations of the relevant stakeholders, in order to be comparable and ensure their relevance for the labour market.**

- "Field-specific" QA systems give credibility and concreteness to the whole "Bologna"/EHEA system.

# Three indicators of relevance
# III – Report - The EU Contribution to the European Higher Education Area, Vienna, 12.03.2010

***Distributed in the Budapest-Vienna Meeting of European Ministers of Higher Educationdo, 11-12 March, 2010***

***On page 8, we can read:***

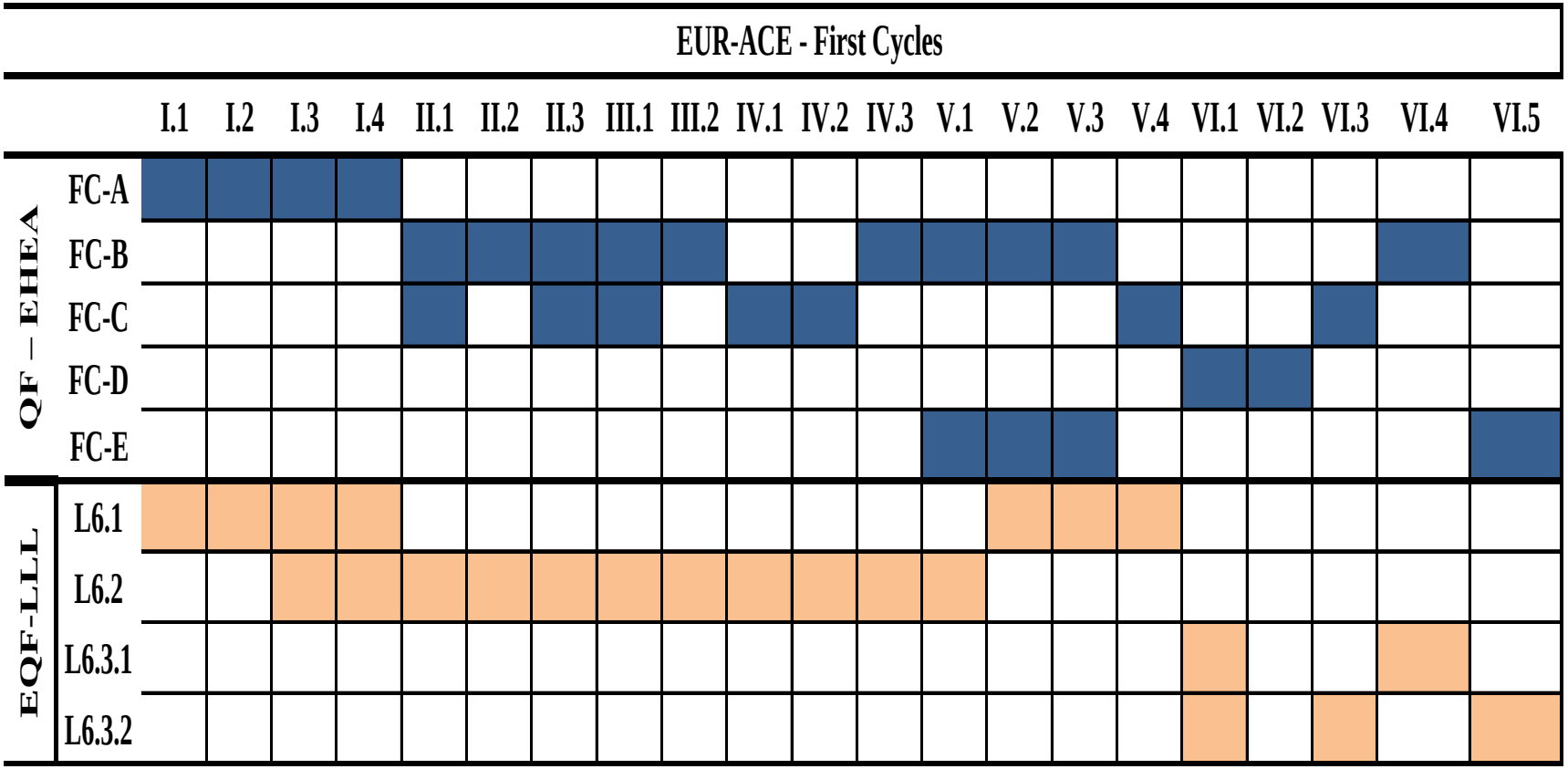
"The Register is open to agencies operating in Europe, be they national or international, public or private, general or subject-specific. **The Commission is supporting the development of a series of subject-specific European quality labels, which could/may lend their standards to existing agencies or become agencies in their own right. Examples include the EUR-ACE label in engineering** and the Eurobachelor, Euromaster and Eurodoctorate labels in chemistry."

# EUR-ACE and the META FRAMEWORKS
## I – Identification of Outcomes (I)

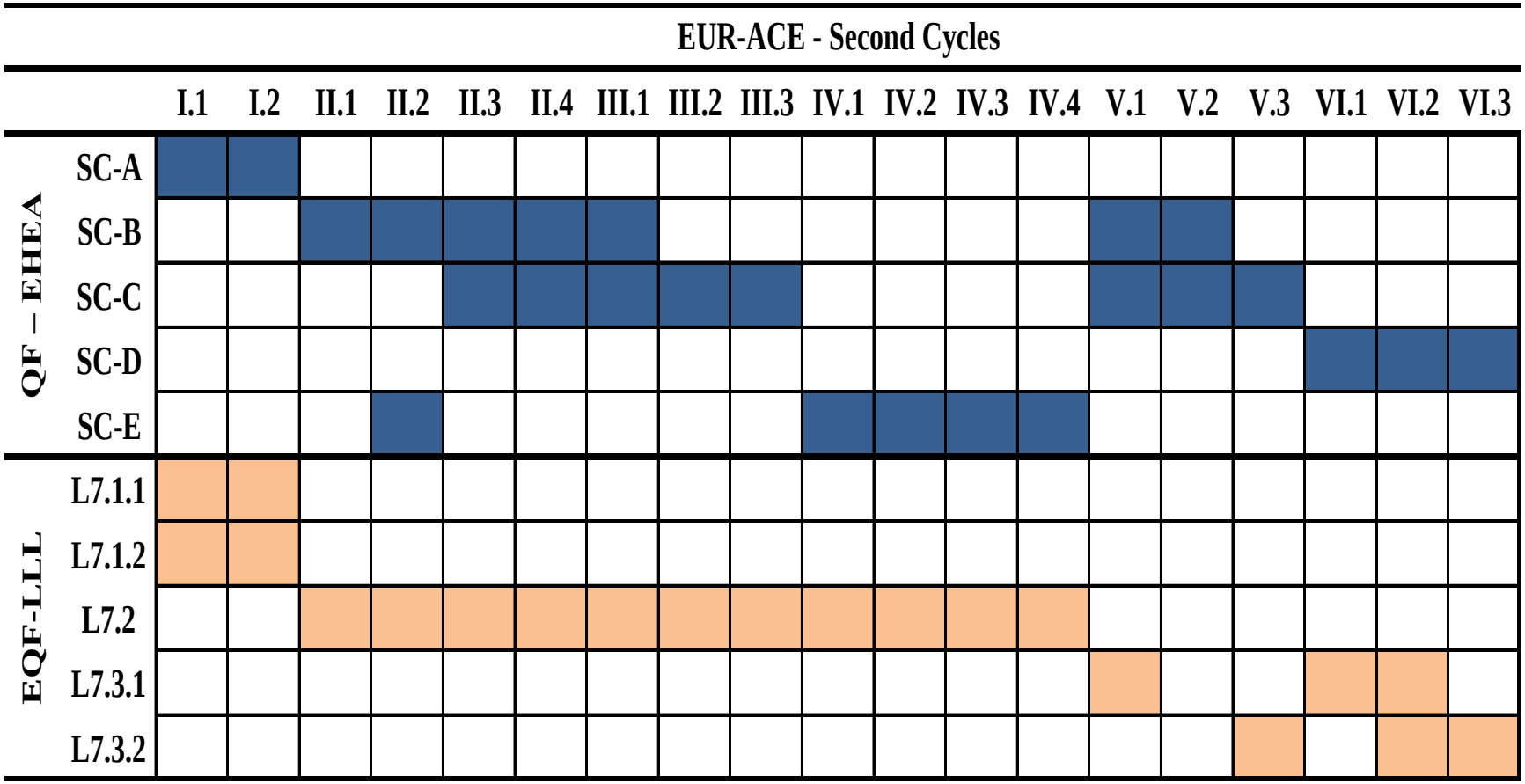
Table 1 - Clustering of qualifications descriptors in different frameworks

| Bologna, QF-EHEA | EU, EQF-LLL | EUR-ACE |
|---|---|---|
| A. Knowledge and understanding | 1. Knowledge | I. Knowledge and understanding |
| B. Applying knowledge and understanding | 2. Skills | II. Engineering analysis |
| C. Making Judgments | 3. Competences | III. Engineering design |
| D. Communications skills | | IV. Investigations |
| E. Learning skills | | V. Engineering practice |
| | | VI. Transferable skills |

# Qualifications Frameworks and Quality Assurance
## II - What is equal, what is different (II)
## EUR-ACE First Cycles / QF-EHEA –First Cycles / EQF-LLL- Level 6



# Qualifications Frameworks and Quality Assurance
## II - What is equal, what is different (III)
## EUR-ACE Second Cycles / QF-EHEA –Second Cycles / EQF-LLL- Level 7



# Mobility - Recognition of Qualifications - Cooperation Qualifications Frameworks

- **Mobility is a distinctive need of Today's Global World**
- **Recognition of professional qualifications is a major task ahead…**
- **Mobility and Recognition require transparent and compatible Frameworks at different complementary layers**
- **Mobility and Recognition of Qualifications are not an illusion, a dream, an objective or a target…**

**They are a MUST…**

**Required for European Development and for**

**Peace and Progress on Earth**