Engineering Council of South Africa

Position Paper

Implementing Engineering Qualifications under the HEQF

1 February 2009

Summary

Engineering professionals are essential in a modern society and their education, training, experience and professional competency must be at an acceptable level. Engineering education qualifications must satisfy professional requirements; they are higher education qualifications and are also subject to prevailing higher education policy. The Higher Education Qualifications Framework (HEQF) was promulgated by the South African Government as the ruling policy on qualifications types and structures. This paper details the Engineering Council's proposal for structuring engineering qualifications within the HEQF. The main recommendations are as follows:

- For persons aspiring to register as Professional Engineers, the existing BEng-type programme will continue. Existing and new three-year degree programmes designed to articulate into the BEng are recognised.
- For persons aspiring to register as Professional Engineering Technologists, dedicated three year bachelors degrees are proposed, decoupling technologist education from that of engineering technicians.
- For persons aspiring to register as Professional Engineering Technicians, two educational routes are proposed. The primary route is via the Higher and Advanced Certificates, with the current practical component deferred until industry training. The second, exceeding the basic requirements, is via a HEQF-compliant Diploma.
- It is indicated that the Certificated Engineer education model is likely to change and proposals for further investigation are given.

The report identifies a number of items that require further investigation. No timescales are given for restructuring qualifications. Reflection on the benefits and shortcomings and actions required by various parties of the HEQF qualification rules concludes the report.

Revision History

Draft	Date	Process
1	15-1-2008	Drawn up based on outcomes of ECSA/ESGB Technology Qualifications Workshop 6-11-2007
2	04-02-2008	Considered by ESGB on 21-02-2008 & ECSA Education Committee on 27-02-2008
3	27-02-2008	Revised following discussion by ESGB ECSA Education Committee
4	02-04-2008	Revised after IPET/SAICE/ECSA Workshop on 1-04-2008
5	28-11-2008	Revised in light of inputs accumulated since 2 April including 6 Nov 2008 Workshop and generated standards. Contains firm proposals for engineering qualifications meeting requirements toward registration.
5.2	13-11-2009	Minor changes.
	12-0102009	Approved by ESGB and ECSA Education Committees

1 Background and Purpose of Position Paper

Engineering is an activity and a profession that serves the economy, society and people. It does so by the purposeful application of engineering sciences, technology and techniques to achieve predicted and effective solutions, using available resources efficiently, and managing risks. Engineering is carried out by practitioners performing distinct roles as evidenced by the categories of registration defined in the Engineering Profession Act of 2000:

- Professional Engineer;
- Professional Engineering Technologist;
- Professional Certificated Engineer;
- Professional Engineering Technician.

The engineer, engineering technologist and engineering technician registration and education models conform to practice in many countries. Occupational health and safety legislation in South Africa requires that certain functions in mines and manufacturing as well as on merchant shipping must be performed by a holder of a Government Certificated of Competency (GCC). Holders are known as certificated engineers and those with responsible experience may register as Professional Certificated Engineers.

The normal mode of development of an engineering practitioner has two important stages. The first involves the attainment of an educational qualification defined for the professional category. The second is completion of a candidacy programme, that is, a programme of training and experience of at least three years. At the end of this period the person must demonstrate the competence required for registration. ECSA accredits higher education programmes that meet the educational requirements for the categories of registration as shown in Table 1.

Table 1: Current engineering higher education qualifications

Category of Registration	Higher Education Qualification Type
Professional Engineer	BEng, BSc(Eng), BIng
Professional Engineering Technologist	BTech, in an engineering discipline
Professional Engineering Technicians	National Diploma (ND), in an engineering discipline
Professional Certificated Engineers	Education requirements specified for entry to GCC Examination (not accredited by ECSA)

The BEng-type of programme, while it has changed over time to meet evolving accreditation criteria, is a well established and stable qualification serving the engineer category. Technology qualifications, that is, those serving the technician and technologist categories, have undergone several changes over time. The ND and BTech have been the accredited qualification types since the early 1990s.

Engineering qualifications meeting the education requirements toward registration are normal higher education qualifications and must conform to national policy. In October 2007, the Department of Education published policy under the Higher Education Act that defines the Higher Education Qualification Framework (HEQF) [1]. The HEQF defines:

- The framework for higher education qualifications as an integral part of the National Qualifications Framework (NQF).
- A set of *qualification types*, their NQF level, credits at exit level and total credits, naming conventions, the broad purpose and characteristics and progression paths.

New qualifications introduced from 2009 must conform to the framework. Existing qualifications must "… conform over time …".

The question therefore arises of whether the engineering qualification types BEng, BTech and National Diploma are compliant with the HEQF. The present BTech can not exist in the new framework and ND technology qualifications do not map seamlessly onto the new qualification types. Engineering technology qualifications have therefore received special attention and proposals for

HEQF-compliant qualifications are given in section 4. A new model for Certificated Engineers has been proposed and creates new requirements for their education which must be met in HEQF-compliant qualifications types.

This paper records the position of ECSA on engineering higher education qualifications that are relevant to the practice of engineering. The objectives are twofold:

- To create an understanding of the common characteristics of the educational qualifications for each category of registration and identification of suitable qualification types within the HEQF. This understanding supported the generation of generic qualification standards to be registered on the NQF.
- To inform and obtain agreement of the Department of Education, the Council for Higher Education and the South African Qualifications Authority[1] on the way that engineering higher education qualifications will be implemented within the HEQF. This agreements is essential to smoothing the approval and accreditation of new programmes, and the transition of existing programmes to new programme types.

This position paper is structured as follows. Section 2 briefly reviews key requirements of the HEQF policy. Section 3 considers qualifications that meet the educational requirements for persons wishing to register as professional engineers. Section 4 presents proposals for new qualifications for engineering technologists and technician education. Section 5 considers educational qualifications for occupations that support the engineering professional categories. Section 6 summarises the system of engineering educational qualifications and their relationship to professional registration. Section 7 reflects on the HEQF rules and identifies problems and possible solutions. Subsequent sections consider a number of issues related to the HEQF-compliant qualifications: international comparability; curriculum design; access, progression and articulation; progression to higher degrees; inter-category articulation and delivery responsibilities. While not strictly part of this study, a note is given on the role of higher degrees in engineering professional development. Given serious concerns about the shortage of graduates from engineering higher education programmes, the potential of proposed model for engineering education to assist in alleviating the skills shortage is evaluated.

2 The Higher Education Qualifications Framework

The HEQF is described in detail in the policy document [1]. It is nevertheless helpful to extract and summarise key information.

The HEQF is part of a 10-level NQF, spanning levels 5 to 10; levels 1-4 remain as currently defined. Level descriptors are referred to in the HEQF policy document but have not been promulgated. ECSA therefore uses a contextualised form of the draft level descriptors published previously for the HEQF [2].

The HEQF permits nine qualification types with main characteristics summarised in Table 2 and shown graphically in Figure 1.

The qualification types, together with entry requirements and indicated progression possibilities, gives a structure to the framework in terms of the qualification types. Figure 1 depicts this structure with the main pathways shown. The exit levels and required credits are shown in boldface.

The Higher Certificate, Diploma and the two forms of Bachelor's Degree provide entry from level 4. The legal minimum admission requirement is a National Senior Certificate, with specified subjects and levels. Applicants with other qualifications may be admitted if judged equivalent by "designated equivalence-setting bodies". The HEQF places the right and responsibility of admission on the

[1] These three bodies have instituted an Interim Joint Committee to consider proposals for new and substantially changed qualifications during 2009 and possibly longer.

provider of the programme who must ensure that the entrant has the required competence to enter the programme

Table 2: Qualification Types permitted within the HEQF

Qualification Type and Exit Level	**Credits: Total and per NQF Level Minima except where shown (≤), Bold = Exit Level**						
	Total	**5**	**6**	**7**	**8**	**9**	**10**
Higher Certificate (L5)	120	**120**					
Advanced Certificate (L6)	120		**120**				
Diploma (L6)	360	≤120		60			
Advanced Diploma (L7)	120			**120**			
Bachelor's Degree (L7)	360	≤96[2]		**120**			
"Professional" Bachelor's (L8)	480	≤96		120	**96**		
Bachelor Honours Degree (L8)	120				**120**		
Postgraduate Diploma (L8)	120				**120**		
Masters Degree (L9)	180					**120**	
Doctoral Degree (L10)	360						**360**

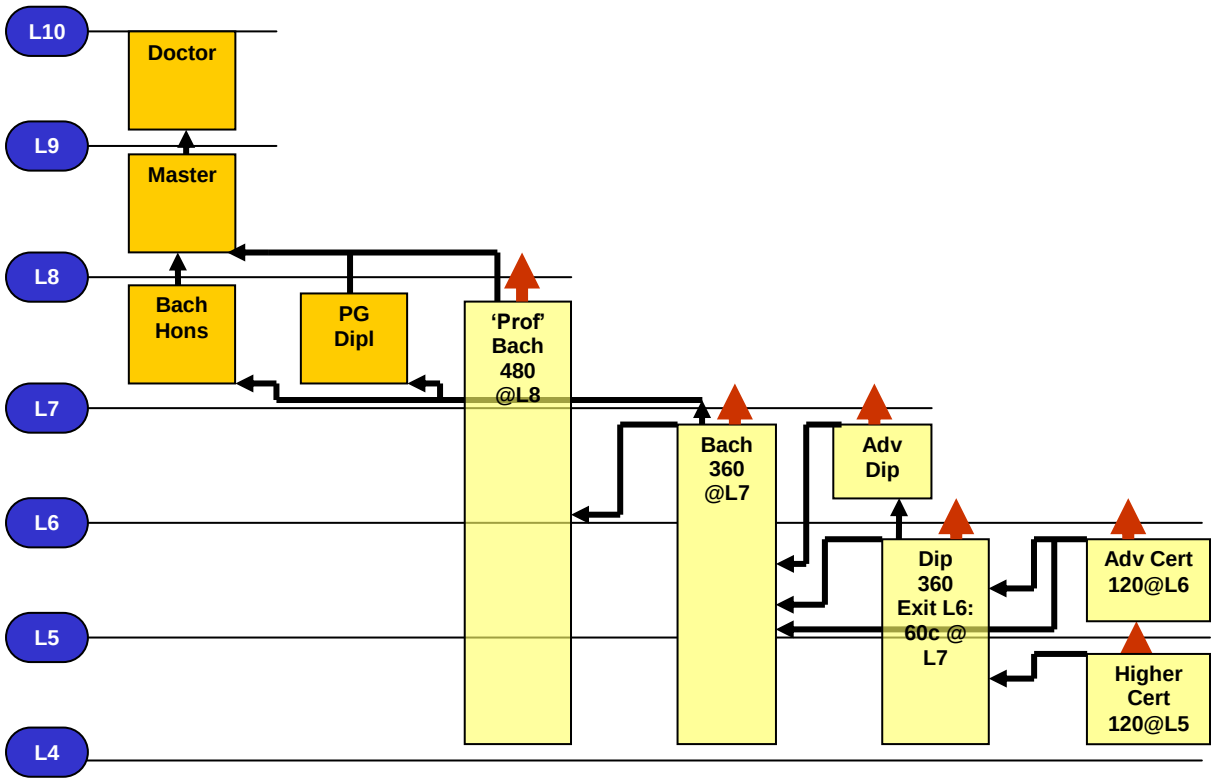

Figure 1: Structure of the HEQF showing progression paths

3 Engineer Qualifications Under the HEQF

The normal or benchmark route to registration as a Professional Engineer requires the completion of a BEng-type degree, followed by at least three years of training and experience before applying for registration. The implications of the HEQF for engineer qualifications are examined below.

[2] These limits have been misinterpreted as limiting the first year of a bachelors degree to 96 credits: it applies to the whole programme. The first year is not constrained to be at level 5.

3.1 The Bachelor of Engineering as a Professional Bachelors Degree

The currently accredited bachelors degree is titled BEng, BSc(Eng) or BIng and is required [4] to have a minimum total of 560 credits with at least 120 credits at the new level 8[3].

The purpose of the BEng-type programme is extracted from the standard in Table 3, together with the baseline of credits in defined knowledge areas. Existing programmes have little level 5 material. This type of programme conforms to the HEQF purpose and characteristics statements, having the higher volume of learning and increased cognitive demand than the level 7 bachelor's degree.

The naming conventions accommodate the BEng form of degree title, for example:

Bachelor of Engineering in Chemical Engineering, abbreviated BEng(Chemical Engineering)

The form Bachelor of Science in Engineering in Chemical Engineering (for example) is problematic as the second element, the designator (of Science), is expected to be specific. Also, this form relegates Engineering to be a subset of Science. This form will have to be changed to BEng in due course. No changes to curriculum content or outcomes will be required in general.

3.2 An Emerging Model for Engineer Education: Three plus two

A number of providers of the BEng-type degree also offer a three year bachelor's degree that *serves an identified purpose in its own right* and also allows the holder to complete an accredited BEng degree in two further years of study. These programmes were put forward for approval at various times prior to the current candidacy phase[4] accreditation system of the Council for Higher Education. Interest exists in proposing further programmes of this type. It is therefore advisable to have guidelines on this general type of programme, to ensure consistency and smooth the SAQA registration and CHE candidacy phase approval of these programmes. The following guidelines are proposed for these degrees:

1. The degree has the purpose defined in Table 3 and must, in terms of objective 2, have a defined area that provides definite opportunities for graduates;
2. The programme must have the intellectual rigour require for bachelor's degrees;
3. The programme must not provide an early exit for failing BEng students;
4. The programme must articulate with a cognate BEng and, where possible, with honours, other professional or comparable programmes;
5. The programme exit level outcomes would be a subset of the BEng outcomes, but pitched at NQF level 7;
6. The content should have a suitable profile that emphasizes mathematical, basic science and engineering science fundamentals but allows study in another field, as illustrated in Table 2;
7. A suitable title is Bachelor of Engineering Science in ……, abbreviated BEngSc(…). Alternatively, it may be possible to structure such programmes under the university's rules for the Bachelor of Science;
8. BEngSc and BSc programmes formally identified in the university rules as facilitating the completion of a BEng degree, will be evaluated in the accreditation process for the BEng Degree and may be accredited as a route to the BEng.

The Engineering Standards Generating Body (ESGB) should define a generic standard for the BEngSc conforming to the above requirements.

[3] Existing level 7. The existing qualifications are registered on the 8-level framework. The ten-level system is used throughout this document.

[4] A higher education provider wishing to introduce a new programme must obtain candidacy phase accreditation from the Council for higher Education, essentially giving permission to offer the programme. The provider must also apply to the Department of Education to have the programme included in the Programme and Qualification Mix to ensure funding.

Table 3: Examples of 3 + 2 degree combinations

Three Year Degree		Target BEng Degree
Engineering Fundamentals Component	**Science Component**	
Electrical Engineering	Biology, Anatomy, Physiology	Electrical Engineering
Mechanical/Chemical Engineering	Chemistry	Chemical Engineering Metallurgical Engineering
Civil Engineering	Geology	Civil Engineering Mining Engineering
Electrical Engineering	Computer Science	Electrical/information/ Computer Engineering
Mechanical Engineering	Physics	Nuclear Engineering
Mechanical Engineering	Applied Mathematics & Statistics	Industrial Engineering
Mechanical Engineering	Biology and Chemistry	Agricultural Engineering

The two forms of three-year bachelors degree, BEngSc or purpose-designed BSc degrees, differ from the BEngTech, proposed in section 4 for technologist education. They are differentiated by their respective orientations, different outcomes and different content profiles.

4 Engineering Technology Qualifications

The current qualifications for technicians and technologists are the National Diploma and BTech respectively.

The National Diploma in engineering fields consists of four semesters of on-campus study, denoted S1 to S4 and two units of work-integrated learning, identified as P1 and P2. The result is a three-year full time equivalent programme. The current programmes are constructed according to NATED 151 [5].

Prior to the promulgation of the HEQF, outcomes-based generic standards for the ND and BTech qualifications had been generated and registered [6]. These could not been implemented by providers or in the accreditation process while NATED 151 was in force. This standard however gives expression to the modern understanding of the exit level outcomes, level of achievement and content baseline that is appropriate for technician education.

It was envisaged that the post-NATED technician education qualification would have 360 credits in total with at least 120 credits at new level 6, thus exiting at level 6. The programme would continue to contain work-integrated learning that would contribute to the attainment of some of the exit level outcomes. The HEQF Diploma-type qualification exceeds these requirements, requiring 60 credits at level 7. In the absence of arguments that the level of technician education needs to be raised, alternative proposals are made in section 4.2.

The technologist is the most recent addition to the engineering team. The current educational requirement is a BTech in an engineering discipline. The BTech in turn requires a National Diploma for entry. As in the case of the ND, an outcomes-based standard had been generated and registered to take over from the NATED 151 specification. The resulting education would be 480 credits that would include the academic component and work integrated learning from the diploma and would add 120 credits at new level 7. The HEQF does not provide for the attainment of a degree by means of a 120 credit programme on top of a diploma. A new form of technologist education is therefore proposed in section 4.2.

4.1 Engineering Technologist Education

Professional Engineering Technologists apply established and newly developed engineering technology to solve *broadly- defined problems*, develop components, systems, services and processes. They provide leadership in the application of technology and commercially effective operations. They work independently and responsibly, applying judgement to decisions arising in the application of technology to problems and associated risks.

Professional Engineering Technologists must therefore have a specialized understanding of engineering sciences underlying a deep knowledge of specific technologies together with financial, commercial, legal, social and economic, health, safety and environmental matters.

Taking the requirements and international benchmarks [8] for technologist education into account as well as the constraints of the HEQF, a new model is proposed for technologist education that is separate from technician education. The model change from the BTech as a one-year add-on to a National Diploma to a three-year purpose designed bachelors degree. The standard for this type of programme is in [9]. This programme would have the following characteristics:

1. The total minimum credits are 420 with a minimum of 120 at NQF level 7.
2. The minimum duration of the programme is three academic years but providers should design programmes that are appropriate to the capability of students at entry.
3. The purpose of the qualification, extracted from the current registered standard, is given in Table 4, together with indicative credits.
4. The programme must have intellectual rigour required for bachelors programmes.
5. The qualification title is Bachelor of Engineering Technology (BEngTech)[5]. The nomenclature BEngTech is used in several Sydney Accord jurisdictions. The qualifier in most cases would refer to an engineering sub-discipline. Examples of qualification titles are:
   Bachelor of Engineering Technology in Structural Engineering abbreviated BEngTech (Structural Engineering)
   Bachelor of Engineering Technology in Mining Engineering abbreviated BEngTech (Mining Engineering)
6. The programme must satisfy the exit level outcomes and knowledge area profile defined in the standard [9].
7. The programme will not require work-integrated learning as comparison with the present system and international benchmarks suggests that the full 420 credits will be required for the academic programme.
8. Some industries may wish to design and deliver training programmes that would complement but not be a part the qualification.
9. The Registration Committee for Technologists may need to modify its Training Guidelines, including respecifying the duration of the candidacy programme.

The new BEngTech degree programmes will have to be accredited by the ECSA's Technology Programme Accreditation Committee (TPAC).

4.2 Engineering Technician Education

Professional Engineering Technicians apply proven, commonly understood techniques procedures, practices and codes to solve *well-defined* problems. They manage and supervise engineering operations, construction and activities, working independently and responsibly within an allocated area or under guidance.

Professional Engineering Technicians therefore require a working understanding of engineering sciences underlying the techniques used, together with financial, commercial, legal, social and economic, health, safety and environmental methodologies, procedures and best practices.

Taking these requirements into account, as well as international benchmarks [8] into account, two proposals are made for HEQF-compliant educational qualifications for engineering technicians in sections 4.2.1 and 4.2.2.

[5] BTech is not permitted as the designator "of Technology" is unspecific while "of Engineering Technology" is acceptable.

4.2.1 Certificate Route for Technician Education

This route is based on the disaggregation of the current national diploma into its academic component (S1 – S4) of at least 240 credits and the work-integrated learning (WIL) component (P1 and P2). The latter is not a requirement for the qualification but must be completed by the graduate who wishes to enter a candidacy programme or employment. Responsibility WIL is shifted from the higher education providers to the employer/SETA sector. The HEQF-compliant proposed qualification is therefore as follows:

1. The educational requirement [10] is an Advanced Certificate (at least 120 credits at level 6) that is built on a Higher Certificate with a combined total of 280 credits. Combinations of programmes would be accredited as meeting the education requirements for engineering technicians.
2. The minimum duration of the combined programme is two academic years but providers should design programmes that are appropriate to the capability of students at entry, including access components where necessary.
3. The purpose of the qualification, extracted from the current registered standard, is given in Table 5, together with indicative credits.
4. The combined programmes must have the knowledge profile and the Advanced Certificate must culminate in the set of exit level outcomes defined in the registered qualification.
5. No work-integrated learning is required within the certificate programmes. Graduates wishing to practice as technicians and to train toward registration must complete training against a standards to be drawn up. This will be based largely on the current P1 module. WIL is to be completed in industry and may be structured as a learnership or skills programme. The WIL may be undertaken after completion of the Advanced Certificate or between the Higher and Advanced Certificate programmes.
6. The ECSA Registration Committee Training Guidelines should recognise a new form of candidacy programme (probably a year longer than at present) that builds on the external WIL programme.
7. The qualification will in terms of the HEQF naming rules be of the form:

   Advanced Certificate in Electronic Engineering, abbreviated Adv. Cert. (Electronic Engineering)

   There is no designator; the word Engineering should appear in the qualifier(s).

4.2.2 Diploma Route for Technician Education

An alternate way of meeting the educational requirement for technicians is via a Diploma as defined in the HEQF. It is recognised that the Diploma, with the requirements for 360 credits total and 60 credits at level 7 will exceed the minimum requirements for technician education. The Diploma, however, proves essential in articulation from the certificate/diploma streams to bachelors degrees.

The Diploma has the following characteristics:

1. The standard [11] defines the diploma in two parts:
   i. Part A has similar total credits and knowledge profile and meets the same exit level outcomes as the combination of Higher and Advanced Certificates;
   ii. Part B includes work-integrated learning (30 credits) and the 60 credits at NQF level 7. WIL must be organised, assessed and quality assured by the educational provider using accepted forms of WIL. The provider is responsible for placement of students in WIL programmes. The requirements for the WIL component are embodied in Exit-level outcome 15.
2. The 60 credits at level 7 in part B must be in the Mathematical Science, Basic Science, Engineering Science or Engineering Design areas. The objective of this restriction is to encourage study that would enable progression to a bachelors degree.
3. The Registration Committee Training Guidelines should recognise a candidacy programme as at present for persons proceeding from the Diploma.
4. The qualification will in terms of the HEQF naming rules be of the form:

Diploma in Electronic Engineering, abbreviated Dip.(Electronic Engineering)
Diploma in Mining Engineering, abbreviated Dip.(Mining Engineering)
There is no designator; the word Engineering must appear in the qualifier(s).

This proposal would require that programmes leading to both the combination of the Higher and Advanced Certificates and the Diploma will have to be accredited by the ECSA's Technology Programme Accreditation Committee (TPAC).

4.2.3 Proposal to Award a Qualification to Persons who have Completed S1-S4

Many students who enrolled for National Diplomas in engineering fields have completed the on-campus four semesters known as S1 to S4 but have failed to secure work placements to complete the P1 and P2 components. Consequently, they have not been awarded the National Diploma.

With the institution of the Advanced Certificate route for technicians, it is now both possible and desirable to recognise the completion of S1 to S4. ECSA recommends that a once-off mechanism be devised to award an Advanced Certificate to such persons.

4.3 The Certificated Engineer

A new model has been suggested for the certificated engineer, which like the present system, will allow several educational pathways to be followed before entering the period of training and experience. The educational level is comparable with a technologist but with special requirements for legal knowledge and mine, plant operations or marine engineering aboard ships. A proposal was made in terms of the existing qualifications, namely the ND and BTech. Programmes could be accredited as meeting the generic technologist requirements and the specific knowledge required by certificated engineers. Attainment of such a BTech would meet the educational requirements to enter a training programme. The mining industry expressed the need to be able to admit trainees to training programmes after a National Diploma on the understanding that a further 120 credits of education would be provided (by an unspecified method) during the training programme.

With the HEQF impacting on the continued existence of the BTech and the change from ND to Diploma, the proposal for certificated engineer education requires revisiting. The following options should be investigated:

1. BEngTech programmes in Mining, Mechanical and Electrical Engineering could be structured to meet the generic level 7 outcomes and the specific knowledge requirements of the certificated engineer. The training programme would be extended to compensate for the absence of work integrated learning in the bachelors degree.
2. As an alternative to 1, Diploma programmes in Mining, Mechanical and Electrical Engineering could be structured to meet the generic levels 6 and 7 outcomes and the specific knowledge requirements of the certificated engineer. The candidate would complete WIL in the Diploma Programme. The graduate could then continue to an Advanced Diploma that would meet the remaining level 7 outcomes and content requirements.
3. The Advanced Diploma may also accommodate persons who have accredited BEngTech generic degrees in electrical or mechanical engineering to attain the specialised knowledge for certificated engineers.
4. An argument could be made that a person who has completed an accredited Advanced Diploma and the WIL is at the level to enter a programme as in 2. Such a person would have to satisfy the entry requirements to the Advanced Diploma by other means.

As in the past, the mining industry requires a pathway for persons who have qualified as artisans to be able to proceed to ultimately become certificated engineers. In addition to their trade, such persons will need Mathematics, Science and Language (English) at NSC or NCV level with symbols specified by the provider. A suitable Higher Diploma programme must be willing to admit the person. Thereafter, the person could proceed to an Advanced Diploma. The WIL component as in 3 is may be credited partly or wholly on the grounds of the artisan qualification.

Table 4: Indicative comparison of Engineering Bachelors degree programme types.

BEng-type		**BEngSc- type programme**		**BEngTech-type Programme**	
Purpose - to build the necessary knowledge, understanding, abilities and skills required for further learning towards becoming a competent practicing engineer. Specifically, the qualification provides graduates with: 1. Preparation for careers in engineering itself and areas that potentially benefit from engineering skills, for achieving technical leadership and to make a contribution to the economy and national development; 2. The educational requirement towards registration as a Professional Engineer with ECSA. 3. For graduates with an appropriate level of achievement in the programme, the ability to proceed to postgraduate studies in both course-based and research masters programmes.		**Purpose (Tentative)** - to build the necessary knowledge, understanding, abilities and skills required for further learning towards becoming a specialist practitioner in a particular area. Specifically, the qualification provides graduates with: 1. A thorough grounding in mathematics, basic sciences, engineering sciences, and an identified specialist area; 2. Preparation for careers in niche engineering and related areas; 3. The ability to readily complete a cognate accredited Bachelors of Engineering Degree; 4. For graduates with an appropriate level of achievement in the programme, the ability to proceed to honours and other programmes for which this degree meets prerequisites.		**Purpose** - to build the necessary knowledge, understanding, abilities and skills required for further learning towards becoming a competent practicing engineering technologist. Specifically, the qualification provides graduates with: 1. Preparation for careers in engineering itself and areas that potentially benefit from engineering skills, for achieving technological proficiency and to make a contribution to the economy and national development; 2. The educational requirement towards registration as a Professional Engineering Technologist with ECSA. 3. For graduates with an appropriate level of achievement, the ability to enter level 8 programmes and then proceed to masters degrees 4. For programmes designed for certificated engineers, achieving proficiency in mining/plant operations and occupational health and safety	
Level Descriptors: Complex engineering problems		**Level Descriptors:** Subset of complex engineering problems		**Level Descriptors:** Broadly-defined engineering problems	
Exit level 8 **Credits**		**Exit level 7** **Credits (Tentative)**		**Exit level 7** **Credits**	
Total	560	Total	360	Total	420
Mathematical Sciences	56	Mathematical Sciences	56	Mathematical Sciences	42
Basic Sciences	56	Basic Sciences	56	Basic Sciences	28
Engineering Sciences	168	Engineering Sciences	84	Engineering Sciences	140
Engineering Design & Synthesis	67	Engineering Design & Synthesis	28	Engineering Design & Synthesis	49
Computing and IT	17	Computing and IT	28	Computing and IT	21
Complementary Studies	56	Complementary Studies	28	Complementary Studies	28
For redistribution	140	For redistribution	80	For redistribution	112

Table 5: Indicative comparison of Engineering Technology and Engineering Support occupation qualification types

Diploma-type Programme			Adv Cert-type Technician Programme		Adv Cert-type ESO programme		Higher Cert-type ESO programme	
Purpose - -to build the necessary knowledge, understanding, abilities and skills required for further learning towards becoming a competent practicing engineering technician. Specifically, the qualification provides graduates with: 1. Preparation for careers in engineering itself and areas that potentially benefit from engineering skills, for achieving technical proficiency and to make a contribution to the economy and national development; ~~2.~~ The educational base required for registration as a Professional Engineering Technician with ECSA. 3. For graduates with an appropriate level of achievement, the ability to enter a Bachelors Degree Programme.			**Purpose** - to build the necessary knowledge, understanding, abilities and skills required for further learning towards becoming a competent practicing engineering technician. Specifically, the qualification provides graduates with: 1. Preparation for careers in engineering itself and areas that potentially benefit from engineering skills, for achieving technical proficiency and to make a contribution to the economy and national development; 2. The educational requirement towards registration as a Professional Engineering Technician ECSA for entry to a candidacy programme with a preparatory component.		**Purpose** The qualification, prepares the learner for an established engineering support occupation (ESO) by incorporating and building on the knowledge gained from a NQF Level 5 engineering qualification to provide: 1. competencies required for the specific occupation; 2. fundamental and further knowledge relevant to and applicable in the specific occupation; 3. learners with management principles appropriate to the specific occupation; 4. sufficient fundamental knowledge to support access, articulation and progression to other qualifications. Curriculum developers will use this generic qualification framework to design their curricula using specified occupation-related content and skills.		**Purpose** The qualification, prepares the learner for an established engineering support occupation by providing: 1. a base of technical knowledge for the specific occupation; 2. competencies required for the specific occupation; 3. fundamental knowledge relevant to and applicable in the specific occupation; 4. learners with management principles appropriate to the specific occupation; and 5. sufficient fundamental knowledge to support access, articulation and progression to other qualifications. Designers of specific qualifications may build on this generic base by specifying occupation-related content and specific skills required.	
Level Descriptors: Well-defined engineering problems			**Level Descriptors:** Well-defined engineering problems		**Level Descriptors:** Well-defined (specific area) engineering problems		**Level Descriptors:** Level 5 ECLD	
Exit level 7			**Exit level 7**		**Exit level 6**		**Exit level 5**	
Credits	**Part A**	**Part B**	**Credits for Higher & Advanced Certificates**		**Credits**		**Credits**	
Total 360	270	90	Total	280	Total	120	Total	120
Mathematical Sciences	28	60 c @ L7	Mathematical Sciences	28	Mathematical Sciences	15	Mathematical Sciences	10
Basic Sciences	21		Basic Sciences	21	Basic Sciences	10	Basic Sciences	10
Engineering Sciences	126		Engineering Sciences	126	Engineering Sciences	40	Engineering Sciences	50
Eng Design & Synthesis	28		Engineering Design & Synthesis	28	Engineering Design & Synthesis	10	Engineering Design & Synthesis	
Computing and IT	21		Computing and IT	21	Computing and IT	15	Computing and IT	15
Complementary Studies	14		Complementary Studies	14	Complementary Studies	10	Complementary Studies	10
Engineering Practice		30						
For redistribution	32		For redistribution	42	For redistribution	20	For redistribution	25

5 Engineering Support Occupations

A large number of focussed, specialised or specified occupations support the engineering process. Functions include completion of designs by insertion of codified detail, development and supply of manufacturing and construction information, quality control, inspections, testing or supervision of production, construction or operations in support of engineering professionals.

These engineering support occupations (ESO) may originate in several ways: they may be generally recognised; may be an industry sector requirement; may be required by an Act or may be regulated by ECSA as specified categories. These occupations have a common set of generic competencies but differ in detailed technical knowledge and work-related skills.

Most of these occupations require educational components at NQF Level 5. Requirements are met by the N6-diploma at present and the Higher Certificates could in many cases replace the N6-diploma. The possible need for higher levels of education in some occupations and the need to provide articulation paths motivated occupationally oriented qualifications at NQF Level 6. These certificates are not identical to those proposed for technician education. Thus, the need exits for additional Higher and Advanced Certificates in engineering support areas. Qualifications have been developed for this purpose.

This type of Higher Certificate qualification specifies the generic requirements for a class of focussed engineering support occupations at NQF Level 5 whose function it is to support engineering activity at the professional level. Persons often enter engineering support occupations from vocational qualifications. This qualification seeks to provide a means of access to higher education and vertical and horizontal articulation to and from other technical qualifications.

This Advanced Certificate qualification specifies the generic requirements for a class of focussed engineering support occupations at NQF Level 6 that require greater depth than cognate NQF level 5 qualifications whose function it is to support engineering activity at the professional level. This qualification provides the basis for articulation of persons who have proved themselves at NQF level 5 toward professionally oriented engineering qualifications for technicians and technologists.

6 International Comparability

International comparability of the qualifications for engineer, engineering technologist and engineering technician is performed primarily through the Washington, Sydney and Dublin Accords. The common benchmark for outcomes and levels of performance are captured in the International Engineering Alliance's *Graduate Attributes and Professional Competencies*. The comparability of the BEng is long established. The new proposals for technology qualifications are felt to be broadly comparable for the following reasons.

- The Graduate Attributes for engineering technician education envisage a minimum of two years of higher education, a set of exit level outcomes that correspond to those envisaged for the combination of Higher and Advanced Certificates, and level/range indicators that correspond to NQF level 6.
- The Graduate Attributes for engineering technologist education envisage a minimum of three years of higher education, a set of exit level outcomes that correspond to those envisaged for the 360 credit BEngTech, and level/range indicators that correspond to NQF level 7.

A need exists to cast the outcomes in a form that is more directly comparable with the Graduate Attributes.

It is natural to draw comparisons between the proposed three year degrees and Bologna first cycle bachelors degrees. Rigorous comparison lies in the future. However, it should be borne in mind that the primary objectives of the Bologna process were harmonising education structures across countries and promoting mobility of students. More recently, governments introduced the objectives of education being an enabler economic competitiveness. Education is measured by volume and there

has not been a strong focus on outcomes or purpose. The contextualisation of the Bologna 3- and 5-year programmes for engineering through the EUR-ACE [14] initiative is a helpful basis for comparison of outcomes. A remarkable omission from the EUR-ACE criteria is a statement of purpose of the first and second cycle degrees. Not surprisingly, professional programmes in engineering, medicine, law and architecture are having most difficulty complying with the first cycle model. It has been said [15] that, having " … broken their five year programmes into a two cycle structure, many are having difficulty defining what their bachelors degrees in engineering are intended to do". Thus, benchmarking against Bologna programmes should be done with care, particularly comparison on the basis of time and degree title.

7 Integrating the proposals

Figure 2 summarises the proposals in sections 3 to 5 and shows the candidacy programmes (CP) that lead to registration in various categories. Levels shown at the left are the new ten-level NQF levels contextualised for engineering [2]. Those on the right are the contextual level descriptors defined by ECSA for engineering at the professional level [3]. These level descriptors contain indications of the demands of practice in each category in terms the level of problem solving and the type of engineering activity as shown in Table 4.

Table 4: Level descriptors used at Stage 2

	Level of Problem Solving	Type of Engineering Activity
S2C	Complex engineering problems	Complex engineering activity
S3B	Broadly-defined engineering problems	Broadly-defined engineering activity
S2W	Well-defined engineering problems	Well-defined engineering activity
S26	Narrowly defined (As S2W in narrow field)	
S25	Consistent with NQF level 5 descriptors	

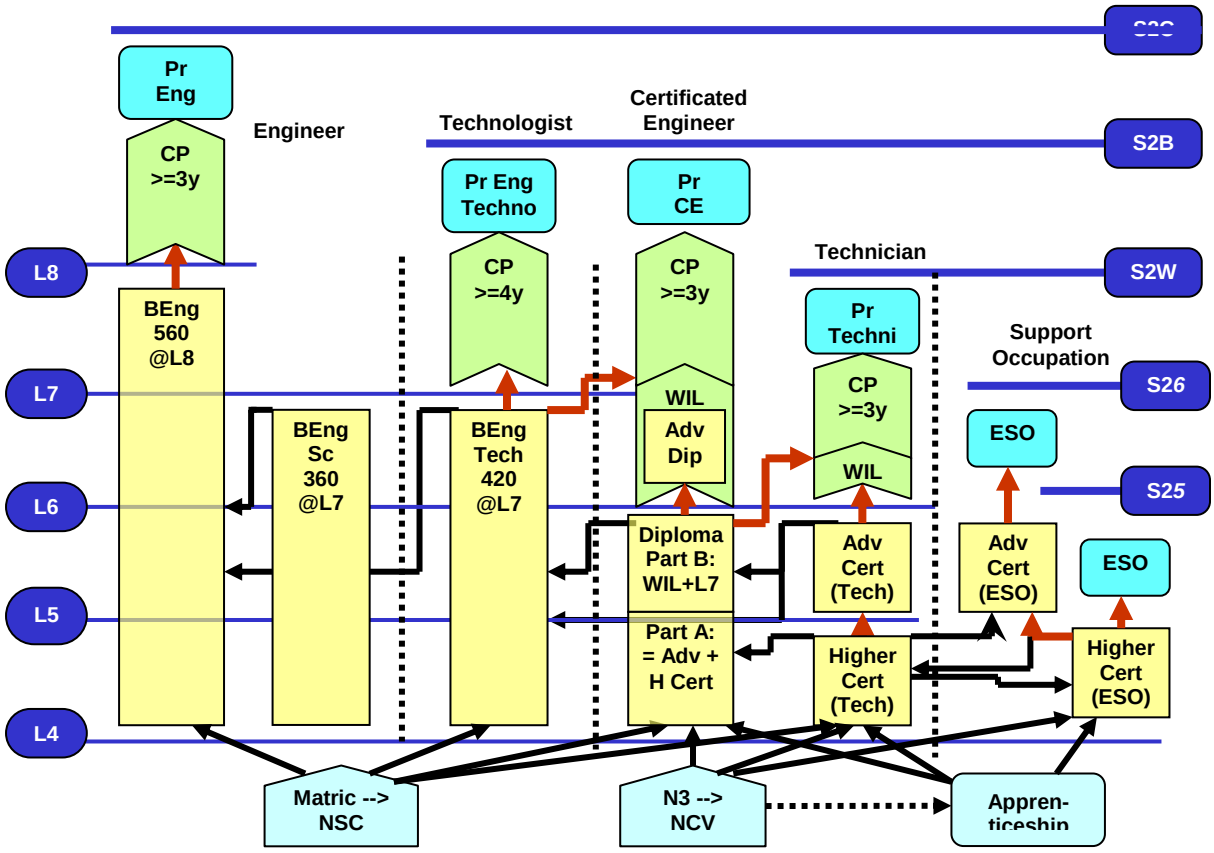

Figure 2: Summarising the proposals: linking education to registration via training

8 Access, Progression and Articulation Considerations

8.1 Access and Progression from NQF Level 4

From 2008 the main level 4 qualification leading to higher education programmes will be the National Senior Certificate (NSC). The NSC requires six 20 credit subjects and the 10 credit Life Skills. Learners wishing to proceed to engineering programmes will require Mathematics, Physical Science and the language of teaching and learning and, if this is not English, adequate proficiency in English. The level of achievement must be that set by the higher education provider of choice.

With holders of the National Senior Certificate entering higher education for the first time in 2009, all will have done either Mathematics or Mathematics Literacy. There is consensus that Mathematics Literacy will not be acceptable for entry to Certificate, Diploma or Bachelors programmes in Engineering. There is also concern that, with the inclusion of Geometry third optional paper in Mathematics, entrants to engineering programmes may be lacking in this area for several years to come.

The minimum entry requirements laid down by the Minister of Education for Higher Certificate, Diploma and Bachelors degree programmes are generally lower that the levels that will be set by individual providers.

A second Level 4 qualification is the National Certificate (Vocational) (NCV). The NCV rules permit subject choices including engineering subjects, Science and Mathematics or Mathematics Literacy. The requirements for entry to higher education programmes are similar: Mathematics, Physical Science and the language of teaching and learning and, if this is not English, adequate proficiency in English. The engineering subjects are not primary entry requirements. The HEQF Policy does not explicitly allow admission of holders of the NCV to the more vocationally-oriented qualifications, namely Higher Certificates and Diplomas. This is despite the NCV being advertised to students as a way of entering higher education.

8.2 Access to Higher Education Programmes by Persons with Trade Qualifications

The current system leading to a variety of trades has several models: single contract apprenticeship, multi-contract learnership, recognition of prior learning and internship for persons who hold a NCV. The entry requirements to the first two are typically grade 9 or 10. The study requirements during the apprenticeship vary. For example the metals sector requires four N2 subjects. Education requirements for most apprenticeships are clearly inadequate to proceed to a Higher Certificate.

To be functionally ready progress to a higher education programme, the holder of a trade certificate must have NCV Level 4 subjects: Mathematics, Physical Science and English with adequate achievement ratings. It is not clear whether this is legally possible: the HEQF policy document states that: “Applicants with different qualifications may only be admitted in [sic] they are judged equivalent by the designated equivalence-setting bodies.” The identity of equivalence setting bodies has yet to be established.

A proposal for further study is the possible use of the Advanced Diploma to give an equivalent qualification to the BEngTech for mature students. A person who has completed an apprenticeship together with Mathematics, English and Physical Science at Level 4 could then proceed in stages by completing Part A of the diploma, Part B and the Advanced Diploma.

8.3 Progression from Academia to Industry

The qualifications defined in this document are conceptualised to meet engineering requirements while complying with the higher education qualification framework. The proposals are based on an agreed division of responsibility for education and training between the higher education providers and industry. Higher education providers must produce graduates to the agreed standards, which are

pitched at the entry point to candidacy programmes. Industry must then train the graduate to the level required for practice.

8.4 Inter-category Articulation

Figure 2 indicates a number of progression possibilities from certificates, to diplomas to degrees. Two cases arise in the HEQF policy. When a student who has completed some credits toward a qualification wishes to change to another qualification, the student may offer all the credits completed that are relevant to the transferred-to programme and must take at least half the credits of the transferred-to programme. Also, 120 credits must be taken at the exit level of a transferred-to undergraduate qualification and 180 for a postgraduate qualification.

The second case is enrolling in a second programme, having completed the first. Here there is a limit of 50% of the credits of the previous programme that can be transferred to the second programme.

A possible route via Honours and Masters has been identified as a way to articulate from technologist to engineer. ECSA's accreditation policy permits providers to submit combinations of qualifications for accreditation as meeting the educational requirements in a category. Such a proposal would be futher tested when the UoTs concerned apply for candidacy phase accreditation to the CHE and to the Department of Education for inclusion of programmes in its Programme and Qualification Mix (PQM). Issues will arise: the purpose of honours, namely, to "prepare students for research postgraduate study" may be incompatible with professional education; the PG diploma with its objective of "strengthening and deepening knowledge in a particular discipline or profession" may be better suited.

8.5 Credit Transfer between Higher Education and Industry Qualifications

A number of engineering qualifications have been registered by industry-based providers and standards bodies at Levels 5 and 6 and exceptionally at Level 7. The issue of credit transfer between these qualifications and higher education qualifications has hardly been addressed.

This matter is for further study.

8.6 Progression to Higher Degrees

The concern is often expressed that graduates of technology programmes should be able to proceed to higher degrees. Proposals for such progression must be grounded on three principles. First, exceptional students are being considered. Second, the HEQF policy document is clear that vertical progression is the primary requirement of the framework. Third, while the Framework indicates progression possibilities, actual pathways can only be created by education providers.

It follows that paths from technology qualifications and especially technician qualifications may not be seamless. We also note that, as has happened over many years, exceptional technology graduates after some time in an occupation that provides good learning experiences are admitted to and are successful at studies at masters level.

Figure 1 shows possible paths that could be created by providers for graduates of BEngSc or BEng Tech programmes, via Honours or Postgraduate Diploma programmes to Masters programmes. The bachelors degree is key to accessing the postgraduate levels. Holders Diplomas or Advanced Certificated would have to articulate into a bachelors degree as the Advanced Diploma does not provide access to higher levels.

8.7 Role of Higher Degrees in Professional Development

Higher degrees can play a role in professional education. ECSA is not concerned with research higher degrees but masters involving coursework can form an important part of initial and continuing professional development, particularly for engineers.

The HEQF policy is clear that one of the two primary purposes of the masters degree is to prepare graduates for advanced and specialized employment. There is the stipulation that masters programmes must have at least 60 credits on "conducting and reporting research". This paper recognizes the role of masters programmes and allows for them to be accredited for particular purposes.

9 Implementation Issues

9.1 A Note on Curriculum Design in Engineering

The standards for engineering higher education qualifications are defined generically with a total credits, exit level and exit level credits, content baseline and a set of exit level outcomes. The ECSA accreditation policy gives providers freedom to define programmes that meet these generic outcomes. The fitness of a programme for a particular discipline is left to the judgement of the peer reviewers in the accreditation process. The possibility exists for defining content requirements for specific types of programmes but this has only been taken up in the case of certificated engineers. Any initiative for specifying additional requirements must come from the relevant community of experts, must not conflict with the generic requirements and must be approved by ECSA.

9.2 Delivery Responsibilities

This paper recognises that in the current situation where the possible providers of programmes are traditional universities, comprehensive universities, universities of technology and, for certificate programmes, FET colleges, the ultimate decision on whether a provider is permitted to offer a particular programme is essentially made with the approval of the DoE and, in the case of Higher Education providers, the attainment of candidacy phase accreditation by the CHE.

The position paper argues for the Higher and Advanced Certificates for technician education. As these are HE qualifications it is implicit that HE institutions could gain approval to run such programmes. However, there is the issue of the FET colleges being permitted to operate in the HE band. If a college has the capacity - and that is a crucial precondition - there would be advantages in offering Higher Certificates that meet requirements for technician education under suitable accreditation and certification arrangements.

9.3 Are these Proposals Conducive to Easing the Engineering Skills Shortage?

In proposing changes to the structure of engineering qualifications, we must be mindful of the medical dictum: *First, do no harm*. Are the proposed changes likely to increase or decrease the supply or improve or compromise the mix of skilled engineering practitioners? The proposed changes should do no harm and they could be beneficial for increasing the outputs of graduates in several ways.

1. The new certificate route alleviates problem of inability to complete P1 and P2 that prevents students from getting their NDs at present. It uses the capacity of the SETAs to get the WIL. (This will need a lot of driving but if it works it will work well).
2. Also, by awarding an Advanced certificate to Students who have completed S1-S4 but not P1 and P2, and making WIL available on a stand-alone basis, such students may be inspired to develop their careers.
3. There is a clear case to increase the number of technologists by a larger proportion that the other categories. To do this at present, we need to put more students through the diploma programmes, with the problems that entails. The UoTs and CUs clearly need more capacity and the creation of the stand-alone degree programmes for technologists is a way of doing that.
4. The two variants of the 3+2 model for engineers both have the potential to produce more BEng graduates, as well as BEngSc and BSc graduates who can perform useful functions in industry. The number of students in the 3-year programme could be expanded by spreading this kind of programme to universities that have quality science programmes bu that do not have engineering faculties.

10 Reflections on the HEQF

The proposals for HEQF-compliant engineering qualifications have been developed under the constraints of the HEQF. The education of future professional engineers is largely unaffected. A suitable qualification type has been found for technologist education but this requires approval of the new type of programme in the various institutions' Programme and Qualification Mix (PQM) and implementation of new programmes. A compromise solution has been found for technician education: the Advanced plus Higher Certificate approach to technician education is likely to be effective but will be cumbersome because of the split qualification and external work-integrated learning. The Diploma route for technicians is an elaborate solution and exceeds the requirements for technician education. The diploma is justified largely on the commonality of Part A described in Table 5 with the certificate programmes and the articulation possibilities it may enhance.

What desirable features are missing from the HEQF and its rules? First, the absence of a 240 credit Level 6 qualification means that the device must be adopted of decomposing technician programmes into Higher and Advanced Certificate programmes; a 240 creit Certificate or Diploma would have been a simpler solution. The decomposition is however not all bad: there are advantages in creating articulation pathways with occupationally-oriented certificate programmes and higher certificates designed as access programmes. The requirement for 60 credits at level 7 in the Level 6 Diploma has not been found to offer advantages for technician education. In fact, designing qualifications with two exit levels poses a number of problems. A 360 credit level 6 Diploma with no requirement for level 7 credits would have been useful. The resulting qualification is likely to prove unattractive to providers.

Second, it seems inevitable that some articulation pathways may not comply with the credit transfer rules that have been set pending the development of a CAT system. The engineering qualifications described in this position paper form a co-ordinated set and ECSA believes that a case can be made for reasonable departures from the proposed credit transfer rules. Students proceeding along predefined pathways are different to those transferring in an ad hoc manner from one stream to another.

Third, the HEQF policy rightly prohibits less demanding qualifications as exit qualifications for students who are not succeeding in more demanding programmes. The definition of a common part of the Diploma programme and the possibility that a student may elect to have the Advanced Certificate awarded and not complete the Diploma in no way implies failure. Similarly, the suggestion that it is important to enable articulation between Higher Certificate programmes for technicians and support occupations is not intended to reward failure. The ESO programmes should not be construe the as exit programmes.

Fourth, we believe that there is an overspecification of required credits in some cases. For example in the professional bachelors degree, there must not be more that 96 level 5 credits, at least 120 level 7 credits and at least 96 credits at level 8. At least 50% of all credits and 50% of the exit level credits must be in the field of the degree. Also students articulating into the programme must do at least 120 credits at the exit level. This numerical puzzle may not be solvable, particularly when the requirements of a profession are added. ECSA has found it completely satisfactory to specify the minimum total credits, the required credits at exit level and a baseline of credits in key knowledge areas. The provider must demonstrate in the quality assurance process that a coherent programme has been designed to take the student from the entry level to the exit level.

11 Recommendations and Responsibilities

A number of recommendations that various parties must act on arise in this paper. These are *tentatively* summarised in the table below, with an indication of the parties that must consider and respond.

No	Recommendation	To
1	The BEngTech model for technologist education be adopted	ECSA RC Technologists TPAC
2	The 3 + 2 model for educating engineers and specialists be adopted as part of the system of engineering qualifications: the BEng and BEngSc degrees are essential components of the HEQF-compliant Engineering Qualifications Framework. A generic standard is required for the BEngSc degree.	ECSA RC Engineers EPAC
3	Two models be adopted for the education of engineering technicians: a) a 240 credit certificate system, with the preparatory work integrated learning being taken over by employers or SETAs; b) a 360 credit diploma incorporating work integrated learning. The generic standards already registered should be revisited	ECSA RC Technicians TPAC
4	SETAs & employers be approached to undertake WIL programmes, high level steering mechanism to be established.	
5	The requirements for candidacy programmes and registration as a candidate technician for engineering technicians be adjusted to accommodate the two models.	ECSA RC Technicians
6	The requirements for candidacy programmes for technologists may require review	ECSA RC Technologists
7	The Certificated Engineer model must be reviewed.	ESGB: CE SGG
8	The ECSA Council consider and adopt the position paper	ECSA Council
9	The position paper be sent to the Interim Joint Committee as ECSA's implementation of the HEQF. Consequential changes to MoU to be identified and actioned.	CHE, DOE, SAQA

References

1. Ministry of Education (2007): The Higher Education Qualifications Framework, Government Gazette, No 30353, 5 October 2007.

2. ECSA (2006b): Contextual Level Descriptors for Stage 1 Engineering Qualifications, Document G-07, Rev-1.

3. ECSA (2006c): Contextual Level Descriptors for Stage 2 Engineer, Engineering Technologist, Engineering Technician and Certificated Engineer, Document G-06.

4. ECSA (2004): Whole Qualification Standard for Bachelor of Science in Engineering (BSc(Eng))/ Bachelors of Engineering (BEng): NQF Level 7, Document : PE-61, Rev-2, Registered on the National Qualifications Framework: NLRD no 48694. http://www.ecsa.co.za

5. Formal Technikon Instructional Programmes in the RSA - NATED Report 151, January 1999.

6. ECSA (2005b): National Diploma in Engineering Technology: NQF Level 6, Registered on the National Qualifications Framework: NLRD no 49744. http://www.ecsa.co.za

7. ECSA (2005a): BTech in Engineering Technology, Registered on the National Qualifications Framework: NLRD no 49509. http://www.ecsa.co.za

8. International Engineering Alliance, Graduate Attributes and Professional Competencies, Ver 1.1 - 13 June 2005, http://www.ieagreements.org/, Accessed 10 Sept 2008.

9. ECSA (2008a): Bachelor of Engineering Technology: NQF Level 6, Submitted for registration on the National Qualifications Framework.

10. ECSA (2008b): Advanced Certificated in engineering disciplines: NQF Level 6, Submitted for registration on the National Qualifications Framework.

11. ECSA (2008c): Diploma in engineering disciplines: NQF Level 6, Submitted for registration on the National Qualifications Framework.

12. National Certificate: Engineering, NQF Level 5, Registered on the National Qualifications Framework: NLRD no 60110

13. National Certificate: Engineering, NQF Level 6, Registered on the National Qualifications Framework: NLRD no 60071

14. EUR-ACE Framework Standards for the Accreditation of Engineering Programmes, http://www.feani.org/EUR_ACE/EUR_ACE1_Main_Page.htm

15. R. Shearman, Bologna: Engineering the right outcomes, International Journal of Electrical Engineering Education, vol 44, No 2, pp 97-100.