The CIRRUS approach towards 'Integration of sustainable development in higher technical education'

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Abstract
Real sustainable development involves a drastic reduction in environmental ánd social effects compared to our present ways of satisfying our needs. A system approach is asked for, taking into account total chains for resource use and production, paying attention to cultural and socio-economic factors when developing and implementing sustainable solutions.
Education has a key-role. Sustainable development will not start nor succeed if education, on all levels, does not adopt it as an important issue.
The 'CIRRUS-approach' put emphasis on attitude and on a system-approach in selecting and implementing effective solutions, technical and non-technical, next to knowledge of specific technologies and tools required to design and assess such options.
It is found essential that it is made an integral part of any curriculum for all students and not be taught in an isolated specialist subject, chosen only by a few interested students.

1 Issues of Sustainable Development

The total impact of human activities on the environment is too much by large, not just for future generations but already for our own sake. Resources are being depleted, ecologies threatened, pollution in many places above the bearing capacity of environment and the social structure on many places disrupted. It directly endangers human prosperity, wellbeing and health. At the same time world-population increases still, economies (must) grow and worldwide people want their legitimate share in prosperity.

All resources, on which our existence and prosperity is based, need to be used much more prudent and efficient. Allowing for the expected population growth (a factor 2 in 40 years), a justified claim for more prosperity globally (a factor 3 to 5) and the presently existing pollution, it is estimated that (eco-)efficiency overall has to increase with something of a factor 10 till 20, and even more to attain real sustainable development. That concerns use of resources (raw materials, energy, water, space etc), emission of pollutants, reduced quality of living-surroundings and loss of ecological values such as biodiversity etc. Totally new processes, products and ways to satisfy our needs are asked for. [1,2,3]
Much is being done. The environmental impact of activities is reduced by optimisation of existing activities, better waste management and increasingly by introducing cleaner processes and cleaner products. Nevertheless, the positive effect of that will be off-set by the ongoing growth. 'Classic environmental management' and pollution prevention through process and product improvement will not suffice in the long run. We need to do better and substantially so. Radically innovative and integrated approaches are needed. 'Fig.1' shows the expected effect of these successive approaches.

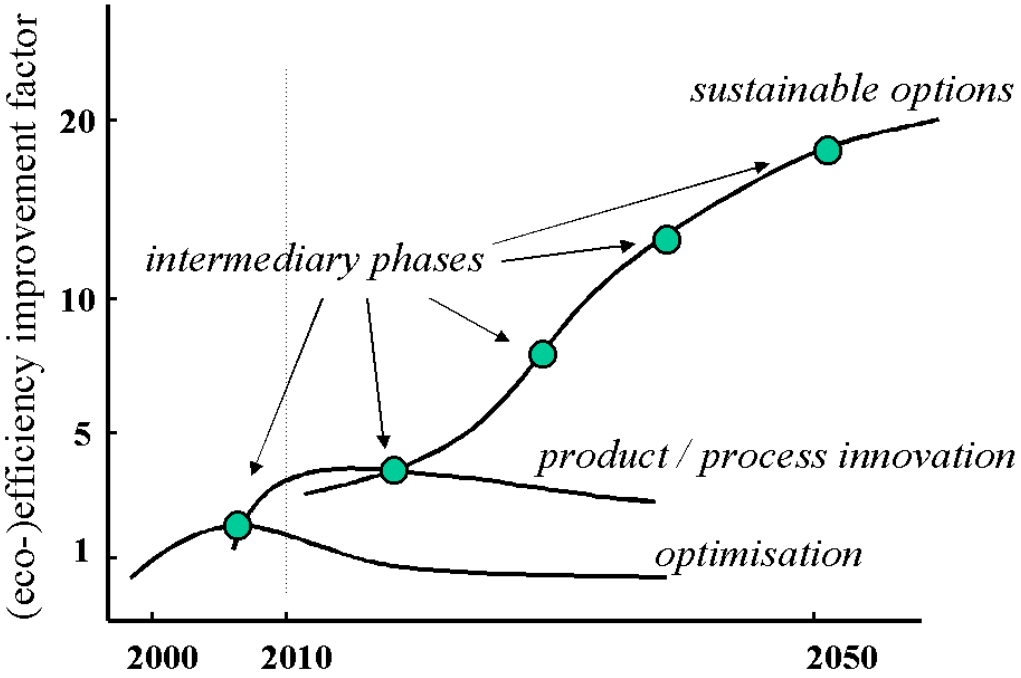


Fig.1 Improvement attainable by successive approaches

What does this imply for chemical engineering?

The contribution of chemical technology constitutes of the process-routes for sustainable energy sources and raw materials based on renewable and recyclable resources. At the same time extremely efficient processes, materials and products have to be developed with minimal environmental impact and are easily recyclable and the necessary (again extremely efficient) recycling processes. 'Fig.2' summarizes the main issues for sustainable chemistry development. [4,5].

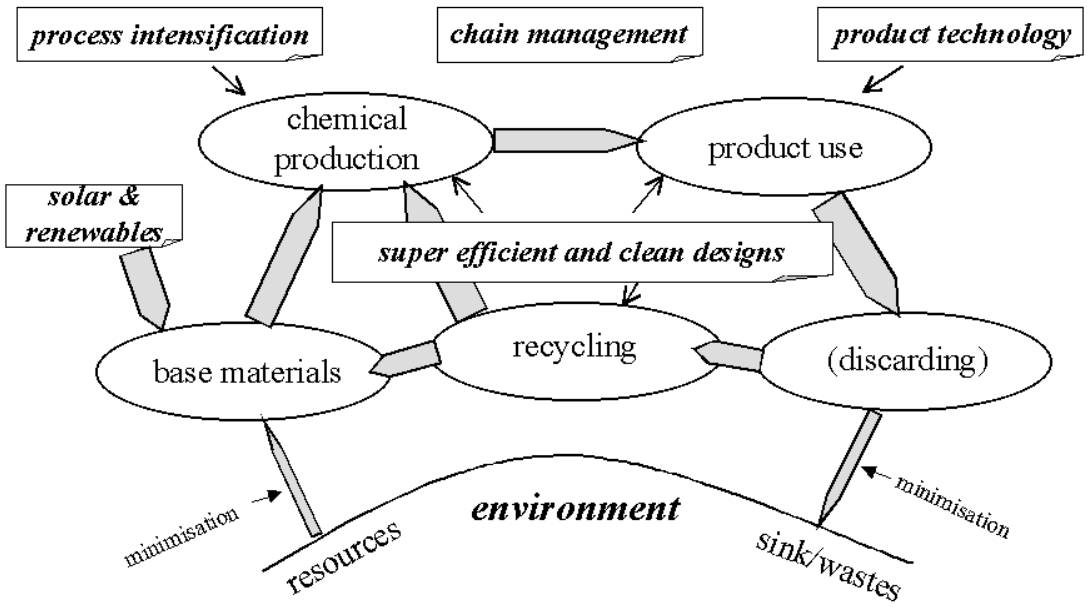


Fig 2. Key issues in chemical engineering towards sustainability

But such a radical approach requires a look at the total socio-economic system instead at only the separate activities, products and technologies. A system approach is require integrating technical, cultural, social and economic factors. Ultimately, sustainability is not a part of technology itself but 'only' determined by the way we use it. Besides sustainable development involves also a well balanced society with minimal social and cultural tensions and equity on global scale.

What does this imply for (higher) education?
The above shows clearly that it is not just some extra knowledge that is needed and be brought into the curricula. Extra knowledge is required but education will have to concentrate too on the methods through which solutions are to be found, how resources, technology, materials and products are to be used and how acceptable and comfortable solutions, also in the long run, can be found and implemented to satisfy present and future human needs and still leaving room also for nature. That is quite a task. Nevertheless all over the world universities have taken up that challenge and share visions and experience [6,7]

2 The CIRRUS Approach

In the Netherlands various initiatives have been taken to that aim. Different approaches exist on the various universities and upe's. Several pilot and demonstration projects have been started. The CIRRUS project is one of these and specifically aims at introduction of sustainable (technological) development (STD) on the technical faculties of upe's. It is sponsored by the Knowledge Transfer and Implementation program of the Dutch organisation for Sustainable Technological Development (DTO-KOV), the national UPE Council and several industries, large and small, which recognise the importance of this.

The key issues and main starting points of the CIRRUS approach are [1] :
- sustainable development requires a paradigm shift in developing, designing and implementing technology, aiming at 'system changes' more then aiming at innovative technologies alone;
- attitude and insight are essential for a really sustainable development oriented engineer;
- training to handle such a 'system-approach' requires interdisciplinary and 'lateral' thinking;
- 'sustainable thinking' has to be an intrinsic aspect of the study as a whole. This means: students still have to become experts in their respective fields, but with extra competences;
- defining how a STD oriented study and curriculum should look like requires fundamental insight in the way society, industry and the professional requirements will develop in the future.

It is ambitious and poses practical and educational complications. Nevertheless the principal idea behind it is that when we consider sustainable development to be essential for all activities within society and all sectors of economy, it cannot be an isolated 'mind-set' for just a few people.

The project involves several steps, described hereafter.

Assessment of future requirements
Sustainable development requires a long term vision, 25 till 40 years. The first graduates of a new ' sustainable' program will leave in about 5 years. They will have active carriers for 35 years thereafter. Assessing the educational requirements for that is a daunting task. Within the framework of the project it is assumed that a study program can be made fitting the requirements of about 2010 which also forms a sufficient basis those graduates can develop their competences further.
A method to assess such requirements is backcasting [3]. It implies the following steps:
- visualize how society might look like, assuming it evolves to sustainability, for different scenario's
- translate this backwards into intermediate phases, in particular ten years from now
- visualise how will industry and others, the students will work for, look like 10 years from now;
- deduce the requirements, the present studies must train for.

[1] and bear in mind that the project presently concerns mainly technical studies!

Backcasting was done regularly within the framework of the Dutch STD program, involving representatives of all groups in society. It forms the basis of our CIRRUS approach and strengthened the arguments for an integrated approach against a separate specialism.

Aspects to be incorporated in educating sustainable (technological) development
In education commonly four levels of training and awareness are distinguished:
- Knowledge
- Understanding
- Skills
- Attitude (and vision)

Each involves own aspects and different approacheswhen imtegrating sustainable development.

Knowledge concerns the basic facts and concepts. That includes environmental pollution issues, resources, possible technological solutions but also the present policies and history of the field, laws and regulations, actions by industry and possible future development scenario's.

Understanding concerns how things work and which paths exist towards sustainable options. Essential is an integrated approach including key-aspects:
- function-oriented: consumer-needs and preferences, requirements of society
- system-oriented: socio-economic fitness, required adaptation of economic structures and behaviour, background of rebound effects, business management issues,
- integral chain management: potential for transfer of problems to other areas, background of integral chain management
- multidisciplinary: contributions of all disciplines, technical and non-technical, cultural issues
- future oriented: short term operational options, tactical and strategic issues

Skills of course relate to the ability and readiness to handle those key-aspects on two levels:
- ability to use relevant 'practical tools' such as LCA, design methodologies as DFA and DFD, exergy analysis, water and energy pinch, and more, often specific for different studies;
- readiness to develop and implement such an integrated system oriented approach, which involves multidisciplinarity, flexibility, ability to work together in projects.

Particular the latter is found essential for developing real sustainable options. It is one of the hardest to learn and to teach however. Problem-oriented education using projects in which students, preferably from different studies, work together is seen as the best method.

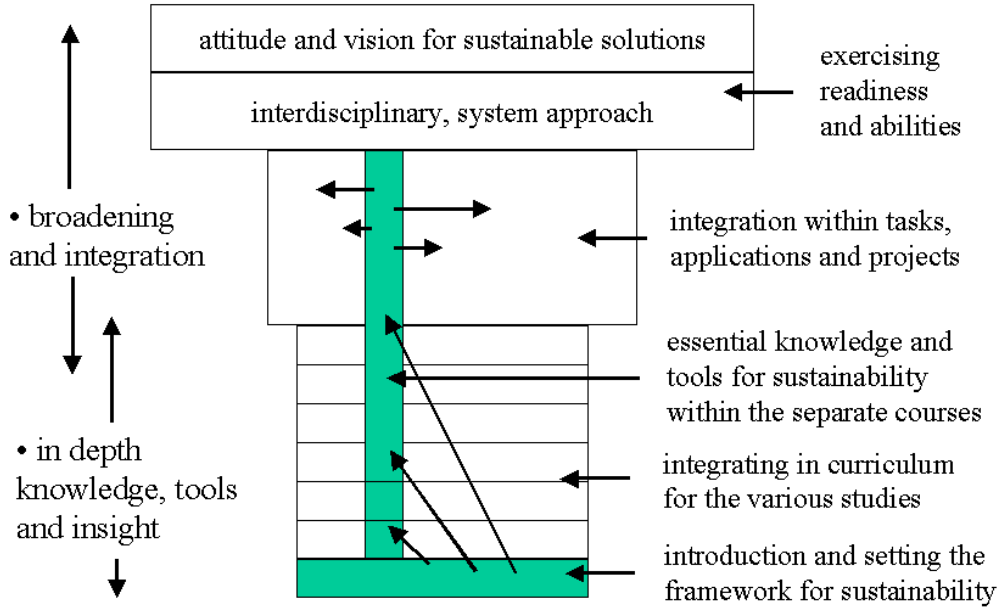
Attitude concerns real commitment. A graduate should 'automatically' use the knowledge, insight and skills for sustainability. To that aim a credible and coherent picture of sustainable development must be presented during all parts of a study showing a vision students can identify with.

Integration Model
To integrate this in the studies a two-track approach is needed: one integrating knowledge and specific skills with tools in the basic curricula and one to develop the general skills and attitude needed for the integrative approach as mentioned before: the so-called 'T-model'.
Starting with in-depth and mostly specific study related knowledge and skills each study takes in its 'regular' curriculum care of the own issues relevant for sustainability. An introduction, a course early in the study or stepwise in successive years more specific knowledge with respect to sustainability is added. It forms a basis for sustainability related subjects within the regular study and to offer multidisciplinary aspects for building up view on the total system.
Attitude and the specific abilities 'real sustainable thinking' such as the system-approach are taught and stimulated during all courses of a study. The various tasks, practical work and projects offer the best opportunity for this. Attention for this is the strongest at the end of a study.
Figure 3 visualises this.

The CIRRUS Program Implementation
The implementation is stepwise:
- a project team of 14 staff-members from each of the (technical) studies involved is trained in sustainability. They will assist introduction, develop teacher and student study materials and intermediate for the various studies.

- study material is made for general introduction of sustainable development and specific subjects as Sustainable Energy, Sustainable Design, Sustainable Business etc. It forms the basis for the individual teachers to adapt their own courses.
- various other necessary 'tools' are made such as a website (www.cirrus.net), an information database and literature collection and a protocol to organise multidisciplinary projectwork for students.
- STD is introduced to the staff of the studies involved and courses set up for specific subjects
- STD is then introduced into the successive years of the studies. It is decided to do this year by year, to a large extent because it so runs parallel with the introduction of other educational changes in the studies, among which competence oriented education and a much stronger emphasis on 'problem oriented education'

The phases overlap. The project has been started February 1999. The total program takes about 5 years.



figuur 3 Integration model for sustainability in a study

3 Present results

Ample experience has been gained still supporting the feasibility of integral implementation. Although obtaining acceptance is difficult, by looking for the best links with each study concerning specific subjects as well as the set-up of its curriculum and education methodology, the validity of the approach is becoming apparent.

Exchange of information and cooperation between the various activities is organised through the Dutch Platform for Sustainable Higher Education and Internationally through the Network of the European Copernicus Program.

A draft for a 'introduction module for sustainable (technological) development' has been made and is distributed to many universities and upe's. Together with them the module will be developed further. An earlier draft was translated and brought into the international Socrates Network.

Several workbooks on specific sustainability issues are being prepared and courses on these subjects are being developed. They are mainly intended for the teachers which have to integrate sustainability into their courses, projects etc. A course on Sustainable Energy has run once.

A format and method to assess to what level sustainable development has been integrated into studies and the organisation of universities and upe's has been drafted called AISHE [8]. It has been adopted as a possible standard, also internationally.

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